MEMORANDUM
RM-6086-PR
DECEMBER 1969

AD703696

THE PILOT TRAINING STUDY:
A Cost-Estimating Model for Advanced Pilot Training (APT)

L. E. Knollmeyer

PREPARED FOR:

UNITED STATES AIR FORCE PROJECT RAND

The RAND Corporation

SANTA MONICA • CALIFORNIA

92

MEMORANDUM

RM-6086-PR

DECEMBER 1969

THE PILOT TRAINING STUDY: A Cost-Estimating Model for Advanced Pilot Training (APT)

L. E. Knollmeyer

This research is supported by the United States Air Force under Project RAND—Contract No. F44620-67-C-0045—monitored by the Directorate of Operational Requirements and Development Plans, Deputy Chief of Staff, Research and Development, Hq USAF. Views or conclusions contained in this study should not be interpreted as representing the official opinion or policy of the United States Air Force.

The RAND Corporation

1700 MAIN ST • SANTA MONICA • CALIFORNIA • 90406

PREFACE

In April 1967, the Office of the Secretary of Defense formed a Pilot Advisory Committee to study "Pilots as a National Resource." The Committee consisted of the Assistant Secretary of Defense, Manpower and Reserve Affairs, and his counterparts in each of the three Services. Representatives of RAND were invited to attend the early meetings of the Committee. The outgrowth was that the Air Force member requested RAND to accept responsibility for examining the Air Force pilot training process. The objective of the RAND Pilot Training Study was to develop a series of computer models for use in estimating the resources required to produce pilots and the costs of training them. Further, the models were to be designed for sensitivity analyses and long-range planning.

For the convenience of readers whose interests may not extend to all aspects of the pilot training process, the results of the study are presented in eight volumes, as follows:

Volume		
I	RM-6080-PR	The Pilot Training Study: Personnel Flow and the PILOT Model, by W. E. Mooz.
II	RM-6081-PR	The Pilot Training Study: A User's Guide to the PILOT Computer Model, by Lois Littleton.
III	RM-6082-PR	The Pilot Training Study: Precommissioning Training, by J. W. Cook.
IV	RM-6083-PR	The Pilot Training Study: A Cost Estimating Model for Undergraduate Pilot Training, by S. L. Allison.
V	RM-6084-PR	The Pilot Training Study: A User's Guide to the Undergraduate Pilot Training Computer Cost Model, by Lois Littleton.
VI	RM-6085-PR	The Pilot Training Study: Advanced Pilot Training, by P. J. Kennedy.
VII	RM-6086-PR	The Pilot Training Study: A Cost-Estimating Model for Advanced Pilot Training, by L. E. Knollmeyer.
VIII	RM-6087-PR	The Pilot Training Study: A User's Guide to the Advanced Pilot Training Computer Cost Model (APT), by H. E. Boren, Jr.

This Memorandum, the seventh volume of The Pilot Training Study, describes the structure and rationale of a cost-estimating model designed to be used in estimating the resources required and the costs involved in providing formal, graduate-level courses for advanced flying training (APT) of Air Force pilots. It was not designed to be used in connection with any postgraduate training (e.g., proficiency flying or upgrade, continuation or special weapons training) or for any program of informal instruction or training.

There are two other memorandums that deal exclusively with advanced pilot training. Volume VI provides an overview of all types of such training and a specific, detailed examination of the categories of formal, graduate-level training for which the APT cost model was constructed. Volume VIII describes the computer program for the APT cost model.

The APT program currently trains pilots in the operation of about 50 different types of aircraft. The APT model provides a framework for estimating the resource requirements and costs for each of these 50-odd aircraft types. The computer program may be used for one course for one year or for any number of courses for any number of years.

SUMMARY

The Advanced Pilot Training Cost Model (APT) is a statement of relationships that may be used, given the necessary inputs, for estimating the resources required and the costs to train pilots in the Air Force formal flying training schools, namely, the Combat Crew Training Schools (CCTS), Replacement Training Units (RTU) and Transport Training Units (TTU). It does not cover such postgraduate training as is required to enable pilots to attain a fully qualified status or the continuation training that is required to maintain their mission effectiveness.

Resources and costs are computed by weapon system on an annual basis for use in long-range planning or sensitivity analyses. The model may be used for any number of weapon systems for any number of years. It may be used separately or in conjunction with the other models developed for the Pilot Training Study. Freedom to vary the inputs enables the user to study the effects of changes in the training program. Results of general interest are printed in a standard table but any or all inputs and outputs may be made available, optionally, for analysis.

Total operating cost, incremental investment cost and operating cost per graduate are computed. Research and development cost may be included as a throughput. Resource requirements include personnel, aircraft and simulators. Facilities are excluded.

This document describes the structure of the cost estimating model and the problems encountered in its development. All of the relationships embodied in the model are explained and examples of its use for sensitivity studies are given.

A comprehensive description of the Advanced Pilot Training Program is given in Volume VI of The Pilot Training Study.* The computer program is described in Volume VIII.*

---

*See Preface.

CONTENTS

FIGURES

I. INTRODUCTION

The Advanced Pilot Training (APT) cost-estimating model, described in this Memorandum, is applicable to graduate-level training courses that have full-time students, a prescribed curriculum and a definite duration. It is not designed to application to upgrade, continuation or special weapons training, proficiency flying or any type of informal training.

There are two other Memorandums that are exclusively concerned with advanced pilot training. Volume VI* provides an overview of the several types of advanced pilot training and a detailed examination of the categories of formal, graduate-level training for which the APT cost-estimating model was designed. Volume VIII* describes the computer program for the APT cost model.

The APT model is intended to be used for:

(a) Long-range planning, not as a tool for current or near-term program management.

(b) Analysis of the sensitivity of advanced pilot training resource requirements and costs to program changes.

It also may be used in conjunction with other models developed in The Pilot Training Study for a comprehensive estimate of the resources and costs of the USAF pilot training program.

In the APT program, students who are already rated as pilots are taught to fly a type of aircraft in which they are not currently qualified. Because of the many different types of aircraft in the Air Force active inventory, the APT program is composed of approximately 50 widely diverse courses of instruction. Each course is controlled by the major command that is the primary user of the aircraft for which the instruction is given. Consequently, there are wide differences in course content, course duration and command policy that had to be taken into account in the design of a general model applicable to all of the formal APT courses. The model was designed so that it may be used for any number of courses and for any number of years.

---

*See Preface.

Another characteristic of the APT program that affected the structure of the model is that many resources used in support of pilot training also provide support for other activities. The need to separate pilot training costs from other costs is, therefore, reflected throughout the model.

The APT cost model consists of detailed statements, in logical sequence, of the relationships among factors significantly affecting the training costs. These relationships--for example, the relationship between numbers of students and instructors--are incorporated in the computer program (described in Volume VIII).* The computer program, given appropriate inputs (number of students, aircraft type and course length), computes the incremental, time phase requirements for personnel, equipment and services and their associated costs.

Section II describes, in brief summary, the scope and principal features of the APT program. Section III provides a general description and Section IV a detailed description of the APT cost model. In the latter, all of the equations used in the calculations are given and described. Section V presents examples of how the model may be used for sensitivity analysis.

---

*See Preface.

II. SUMMARY DESCRIPTION OF ADVANCED PILOT TRAINING PROGRAM

This section provides a brief description of the Advanced Pilot Training (APT) program for the convenience of readers who have had no experience with it or who have not read the more comprehensive explanation contained in Volume VI.* This is done because a general familiarity with the Advanced Pilot Training program is a prerequisite to an understanding of the description of the APT Model contained in Sections III and IV. For this reason, the brief explanation that follows is focused on aspects and elements of the program that significantly influenced the construction of the APT Model.

SCOPE OF APT TRAINING ACTIVITIES

Pilot training includes precommissioning training, Undergraduate Pilot Training (UPT), survival training, advanced pilot training and upgrading, continuation and proficiency training. Additionally, many pilots are given special weapons courses, and some are trained as flight instructors.

The APT Model is applicable to the advanced pilot training segment of this series of training activities. It is designed primarily to estimate the resources required and the costs for _formal_ transition- and missions-qualification courses for pilots. These courses are conducted by units variously referred to as Combat Crew Training Schools (CCTS), Replacement Training Units (RTU), Transport Training Units (TTU), or by the general designation of Advanced Pilot Training, depending upon the organization that conducts the training. As used in this Memorandum, a formal training program is one that has full-time students, a prescribed syllabus and a definite duration. Although it was not so designed, the APT Model may be applicable to other advanced pilot training courses (such as special weapons courses and courses for instructor pilots) provided that the required inputs are available.

Advanced pilot training programs are also referred to as advanced _flying_ training programs because they provide training for nonpilots

---

*See Preface.

(such as navigators, radar observers, and electronic warfare officers) concurrent with the training of pilots. This study is concerned only with advanced training of pilots.

Combat Crew Training Schools (CCTS) are the basic organizations for advanced training of pilots in aircraft weapon and tactical support systems within the Tactical Air Command (TAC), Aerospace Defense Command (ADC) and Strategic Air Command (SAC). When CCTS training capacities are exceeded, the student overflows are accommodated by Replacement Training Units (RTU) established within tactical units. The courses of instruction are essentially the same. The only salient difference between CCTS and RTU training is that the former is conducted by training squadrons, i.e., by squadrons whose primary mission is training, whereas operational squadrons conduct the RTU instruction while continuing to maintain their operational readiness posture.

The Military Airlift Command (MAC) conducts the TTU training program for pilots of heavy transport aircraft. Also, MAC provides air rescue training utilizing both fixed- and rotary-wing aircraft.

The Air Training Command (ATC) refers to its courses, subsequent to Undergraduate Pilot Training (UPT), as Advanced Pilot Training courses. Currently, the ATC trains helicopter pilots, foreign pilots, and some instructor pilots in its advanced pilot training program.

PRINCIPAL FEATURES OF APT PROGRAM

The following features and characteristics of the formal advanced pilot training programs had important bearings on the design of the APT model.

Course Curriculum

Each of the advanced pilot training courses has a prescribed syllabus with a specific number of hours scheduled for ground school classroom work, flying training, and, for most courses, simulator and trainer instruction. There are considerable differences, however, in the mix of hours allotted to classroom, simulator and flying instruction.

Skill Level Required

The skill level that students are expected to attain before graduation varies from course to course. Graduates of some courses are classed as combat ready, but graduates of many courses are given additional training in an operational unit before being considered combat ready.

Course Duration

Course lengths vary from two to 30 weeks depending mainly upon the complexity of the aircraft system. Course length is also influenced by the particular mission for which the student is being prepared, by the student's prior experience as a pilot and by individual student aptitudes.

Joint Training

Student crews in the advanced flying training program often consist of both pilots and nonpilots (e.g., navigators and radar intercept officers). Also, in many cases, more than one pilot is given instruction during one training flight.

Multiple Missions

At present, every base that hosts an advanced pilot training program has other missions.

Student Pilot Classifications

In the context of this study, all Air Force aircraft are classified either as Fighters or as Bomber/Cargo aircraft.

Similar Aircraft Pilots. An APT student is classified as a "similar aircraft pilot" if he is to receive his APT instruction in an aircraft of the same category as the one that he piloted during the tour of duty immediately preceding his assignment to the APT school.

Dissimilar Aircraft Pilot. This is the converse of the preceding definition; i.e., a student is considered a "dissimilar aircraft pilot"

if his APT instruction is to be given in a different category of aircraft (Fighter or Bomber/Cargo) from that which he piloted during his previous duty tour.

UPT Graduates. These are student pilots who enter an APT school directly from Undergraduate Pilot Training (UPT) and who, consequently, have had military flight instruction only in UPT aircraft.

Desk Job (Supplement) Pilot. A desk job or supplement pilot is one whose previous assignment did not include flying as the primary duty.

Instructors

Some ground school classes are taught by nonpilot FTD (Field Training Detachment) personnel. The remainder of the ground school instruction, all flying instruction and most simulator/trainer instruction are given by pilot-rated personnel. Some nonteaching man-hours are related directly to the primary mission of student training, e.g., course supervision, proficiency and standardization-evaluation flights, and instructor-refresher training. Such instructor-orientation or refresher training, as required, is usually given at the base to which the instructor is assigned rather than at a separate school for instructors. A distinction is made between instructor man-hours that contribute to student training and those that are spent on such unrelated duties as flying special missions or teaching courses outside the scope of APT training.

Numbers and Types of Aircraft Used

There are wide differences among APT courses in the numbers and types of aircraft that are used. Training is given in both rotary- and fixed-wing aircraft and in aircraft ranging in size from the B-52 heavy bomber to the O-1 FAC (Forward Air Control) aircraft. Some courses require only one type of aircraft for the training; others use as many as five. For example, all tanker pilot instruction is given in the KC-135, but a single-seat fighter pilot may receive instruction in (a) a lead-in trainer, (b) a two-seat trainer version of

the primary aircraft, (c) the primary aircraft and (d) a special equipment trainer. Fighter-pilot training also requires target-towing aircraft for gunnery and missile-firing practice.

Additional Aircraft

When a new aircraft system is added to the Air Force inventory, provision is usually made for the procurement of a sufficient number of aircraft to meet the needs of the APT program, including the need for attrition replacements, over the entire service life of the aircraft system. For this reason, the need for additional training aircraft will almost always be met from existing inventories. Moreover, supplemental procurements would seldom be obtainable because the production of any given type of aircraft is usually halted as soon as the originally-established procurement level is met.

Course Locations

For some aircraft, all of the instruction is conducted at one base; for other aircraft, the same training is provided at several bases. In most courses, the student receives all of his training at one base, whereas, in a few cases, the instruction is begun at one base and completed at another.

Facilities

Minor construction and modification of facilities are included in annual civil engineering costs. Some major construction, such as a new hangar, may occasionally be required. This however, would be an exceptional circumstance because facilities for advanced flying schools are usually obtained by taking over existing facilities rather than by constructing new bases and facilities. The expectation is that this will hold true in any future expansion of the APT program--i.e., any additional schools will be established on existing bases and they will occupy buildings already in place.

III. GENERAL DESCRIPTION OF THE MODEL

This section provides a general description of the structure of the APT model and of the estimating relationships involved. It is intended as an overview (prefatory to the detailed explanations given in Section III) to facilitate understanding of the model's composition and of the equations used in the estimates.

The explanation is presented in four parts. First the pattern, or flow, of operating cost relationships is diagramed and discussed in step-by-step sequence. The second part deals, similarly, with investment cost relationships.[*] The third part explains why certain elements of expense have been excluded. In the concluding part, some additional questions affecting the composition of the model are discussed.

OPERATING COSTS[**]

Except for aircraft recurring investment costs, and simulator/trainer material and services costs, all operating cost calculations are based either on numbers of people or numbers of flying hours. This makes it possible to segregate costs properly chargeable to pilot training from those incurred by other activities on the base. Pilot training is charged only with the permanent party personnel needed to support the pilot training course. The same concept applies to flying hours.

Figure 1 is a simplified diagram that shows, sequentially, the relationships by which the operating costs are estimated and that serves to illustrate the narrative explanations that follow. In general, the calculations that are made at each step provide the basis for those made at the next ensuing step.

---

[*] Operating and investment cost relationships are interwoven throughout the structure of the model but are discussed separately here to facilitate explanation.

[**] As used here, "operating costs" include maintenance.

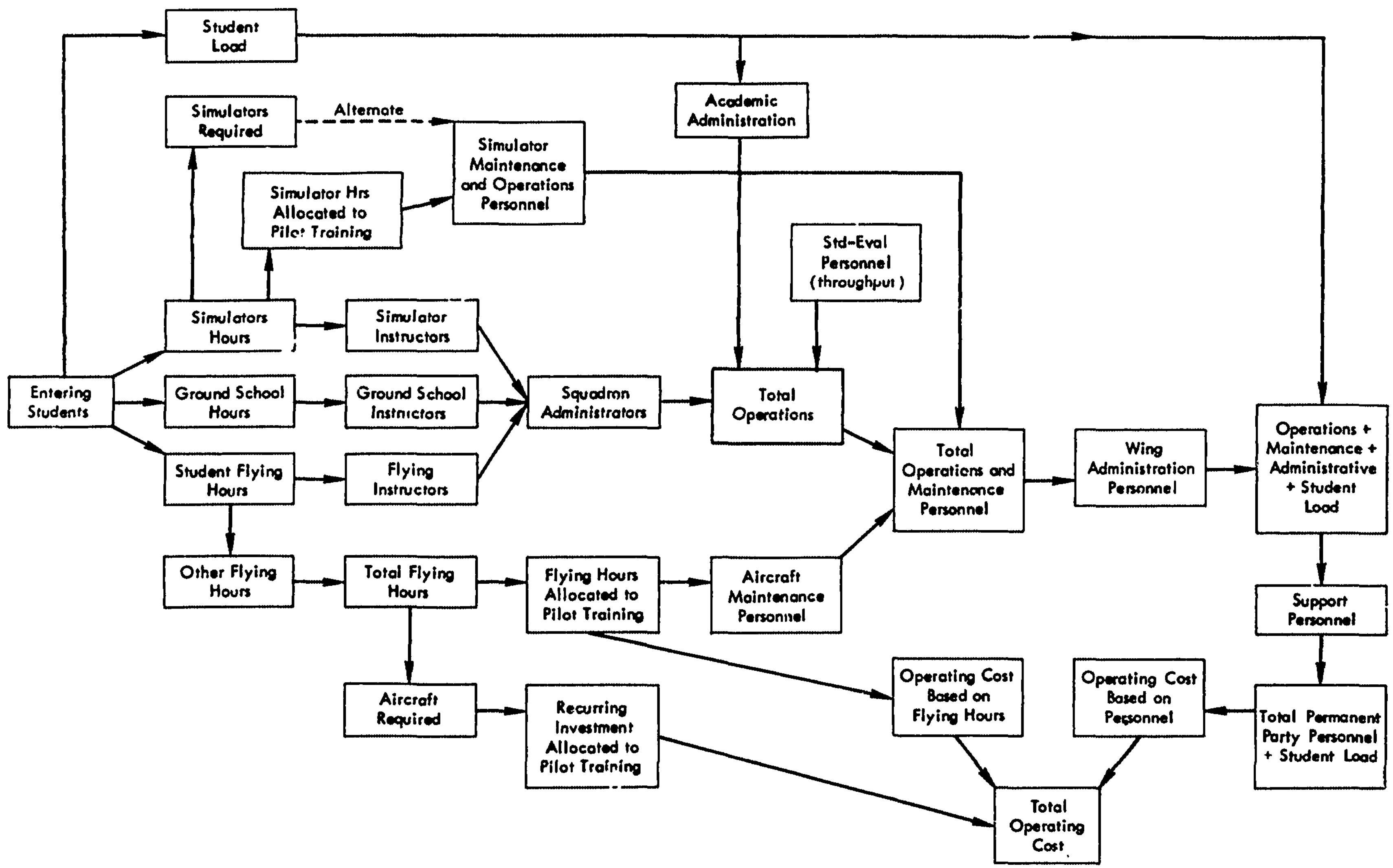


Fig. 1--Operating Cost Relationships

Training Hours and Instructors

Starting with the number of students and given the number of training hours per student in a course syllabus, calculations are made of the total number of ground school classroom hours, simulator hours* and flying hours required. Then, given the total training hours required and the number of hours each type of instructor normally teaches per year, the number of instructors needed for ground school, simulators and flying are computed by dividing the instructional hours required by the average number of hours per year that an instructor is available to teach.

This procedure permits variations in a course syllabus and computer calculation of a revised instructor requirement which, of course, implies a different instructor-student ratio.**

Other Squadron-Level Operations Personnel

The supervisors of the instructors and their administrative personnel at squadron level are computed as a fixed number plus a percentage of the number of instructors. The personnel who administer the academic program are computed as a fixed number plus a percentage of the average student load. (In both cases, including a fixed number of personnel is optional).*** Standardization/evaluation personnel are treated as a fixed input since there is no standard estimating relationship applicable to all commands.

Operations Personnel - Total

The numbers of instructors, supervisors, administrative personnel and standardization/evaluation personnel are combined to produce the operations (as distinguished from maintenance) personnel total.

---

*The treatment of instrument trainers is similar to that of simulators. In this section, to simplify the discussion, only passing reference is made to trainers.

**Instructor-student ratios were available for some courses but were not used because any variation in the courses would require that new ratios be developed outside the model.

***This option is discussed in detail beginning on page 20.

Flying Hours

The flying hour total as shown in Fig. 1, includes "Student Flying Hours" and "Other Flying Hours." The latter consists of some, but not all, hours flown by instructors and other staff members. Hours flown by instructors with students in the same aircraft should be excluded to avoid double counting. Instructor hours flown with students but in separate (lead or tow) aircraft must be included in the "Other Flying Hours" category.

Total flying hours should be increased by some reasonable percentage representing nonstudent flying hours* that are properly chargeable to pilot training although not flown with students. Examples are training hours for instructor pilots and a portion of the hours that the school staff logs (other than with students) on test, proficiency and ferry flights. No fixed percentage is prescribed because it must be based on the informed judgments of those who use the model.

Aircraft, Simulators and Trainers Required

The required number of aircraft is estimated by dividing total flying hours by the number of hours available per year from one airplane. In the same way, the number of simulators and trainers required is computed by dividing the number of simulator or trainer hours by the number of hours available per year from one unit.

Allocation Fractions

At this point the user of the model must decide what portion of the crew flying and simulator hours are to be allocated to pilot training. If the training is in a single-seat fighter, all of the hours and related costs should be charged to pilot training. If, however, pilots and nonpilots are trained together, as in B-52 bombers, the user should allocate only a part of the hours and related costs to pilot training. Therefore, the user must input a pilot allocation

---

*No provision is made for a corresponding addition to student simulator hours because simulator/trainer use by the staff is limited and the incremental cost is inconsequential.

fraction for each type of aircraft--100 percent for the single-seat aircraft and such lesser percentages as the user considers appropriate for other types--in order to calculate the number of flying hours to be charged to pilot training. An allocation fraction must also be input for simulators since pilots and nonpilots are trained together on the simulators for some types of aircraft. Because instrument trainers are used only to instruct pilots, no allocation fraction is required for trainers.

Through a chain reaction, the allocation fractions selected will affect the total number of permanent party personnel and the costs charged to pilot training.*

Aircraft Maintenance Personnel

The number of aircraft maintenance personnel required is calculated by multiplying the number of flying hours charged to pilot training by the number of maintenance man-years required per flying hour.

Maintenance and Operations Personnel for Simulators**

As shown in Fig. 1, the model provides two methods of computing the number of maintenance and operations personnel for simulators. One is based on simulator hours; the other on the number of simulators required. The alternatives are these:

a. The allocation fraction is applied to simulator hours to determine, first, the number of hours to be allocated to pilot training and, then, by chain reaction, the number of maintenance and operations personnel to be charged to pilot training.

---

*Special note is made of the fact that the allocation fractions are not applied to the computation of personnel included in the "Total Operations" element. As explained above, the requirements for instructors, instructor supervisors and squadron administrative personnel are based on the number of student pilots entering training.

**Maintenance of simulators is accomplished by the same personnel that operate them. Because there is no practicable way to differentiate between maintenance and operating man-hours, the Air Force treats them as inseparable.

b. The other option is based on the number of simulators required. The staffing allowance is determined by multiplying the number of simulators by the number of maintenance and operating personnel authorized per simulator and then applying the allocation fraction for simulators.

Wing-Level Administrative Personnel

At the next step, maintenance and operating personnel requirements are combined and the wing-level administrative personnel requirements are estimated as a percentage of that total. The model gives the user the option of including a fixed number of wing-level personnel even though it will seldom be possible to identify wing level individuals whose duties are exclusively concerned with a single pilot training course.

Support Personnel

Support personnel requirements are determined as a percentage of the total operations, maintenance and administrative (wing level) personnel plus the average student load. The option of using a fixed number of support personnel is also available.

Total Operating Cost

Having the numbers of personnel and the flying hours required, operating costs in various categories are computed as so much per person and as so much per flying hour. Exceptions:

a. Target rental is a throughput.

b. Aircraft recurring investment* is computed as a percent of the cost of the required aircraft with the allocation fractions being used to determine the amount chargeable to pilot training.

---

*As defined in Air Force Manual 172-3, USAF Cost and Planning Factors Manual, 27 October 1967 (Revised), "recurring investment" for aircraft is the cost of modifications plus spares, common AGE plus spares and component improvement. In conformance with Air Force practice, recurring investment is classified, in this Memorandum, as an operating expense.

c. Simulator/trainer costs for material and services are based on the number of simulators and trainers. The simulator allocation fraction is applied to determine the portion of the cost chargeable to pilot training.

Total operating costs divided by the number of graduates gives the cost per pilot for each type of aircraft.

INVESTMENT COSTS

The investment costs are incremental costs; no attempt is made to estimate investments made in the past ("sunk costs") and no depreciation allowances are included for equipment or facilities.

Figure 2 is a simplified diagram of the relationships used to estimate investment costs.* Figure 2 begins with the results of computations depicted in Fig. 1.

Aircraft Investment

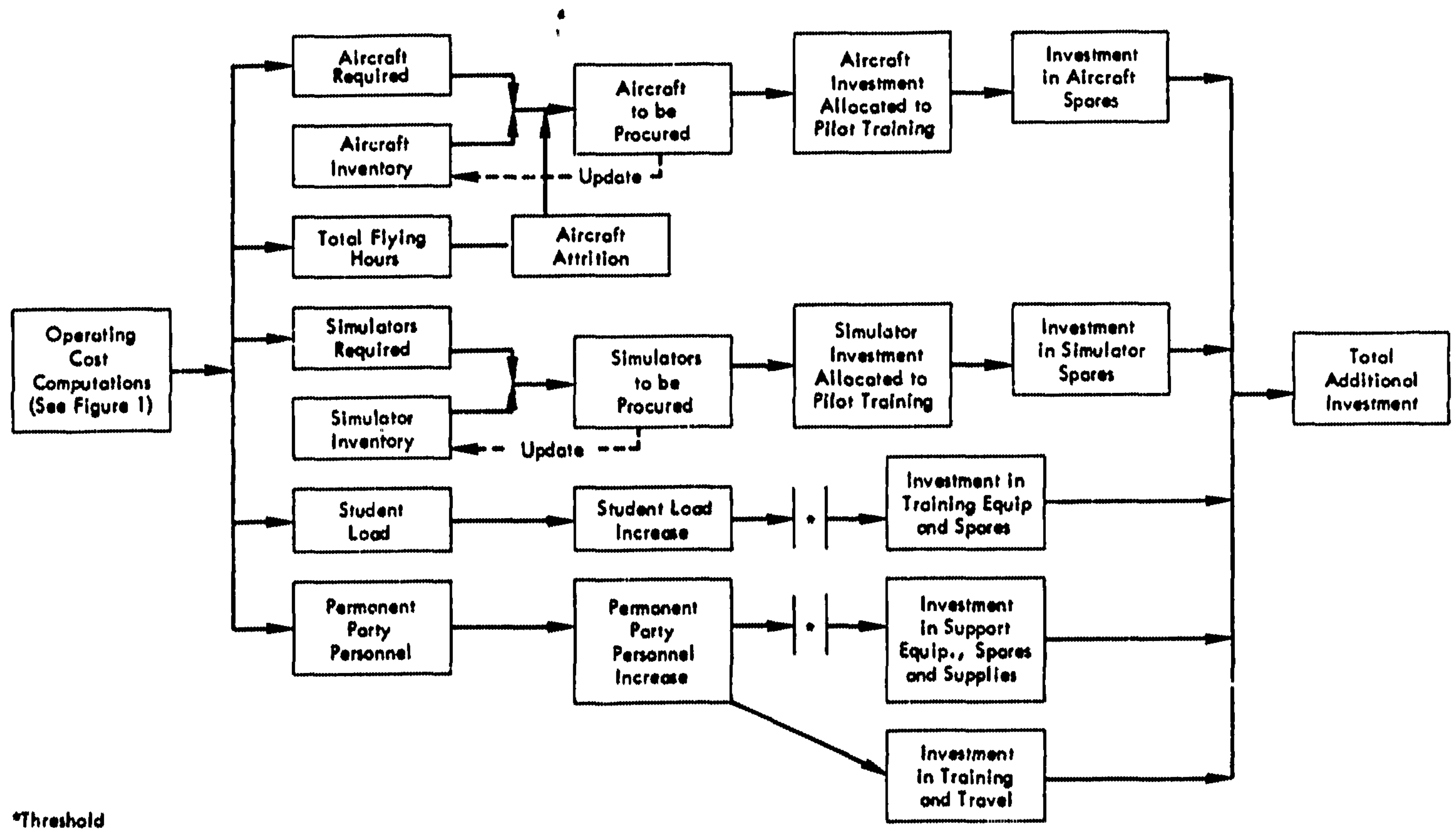
If the number of aircraft required exceeds the current inventory, the number of additional aircraft needed, including those required to offset attrition, is computed. Aircraft attrition is a function of total flying hours before application of the allocation fraction. The aircraft inventory is increased by the number procured and decreased by the loss due to attrition. Even if the inventory is sufficient for the current year, attrition losses may subsequently reduce it to the point where more aircraft need to be procured. This calculation is done for each type of training aircraft used.**

The cost of the additional aircraft required, including peculiar support costs, is charged to pilot training in whole or in part depending on the allocation fraction used. Investment in aircraft spares is

---

*As explained above, operating and investment cost relationships are diagramed separately to facilitate presentation; within the model they are intermeshed.

**The model provides for the use of three types of aircraft in a single weapon system course. See page 24.



*Threshold

Fig. 2--Investment Cost Relationships

a percentage of the aircraft investment allocated to pilot training. It is assumed that the investment in aircraft and spares occurs in the year in which the requirement develops.

Simulator/Trainer Investment

Simulator and/or trainer investment computations parallel those for aircraft except that there is no attrition allowance. If the number of simulators required exceeds the inventory, the difference is the number to be procured and added to the inventory.

New investment in simulators is the portion of the cost of the simulators procured that is allocated to pilot training. Investment in simulator spares is a percentage of this cost. Investment in additional instrument trainers is not prorated because they are used by pilots alone and no computation of trainer spares is included because the costs are small.

Other Investment

When the student load increase exceeds a reasonable threshold value, selected by the user, an initial investment for training equipment and spares is computed on the basis of an estimated amount per student.

When the selected threshold for permanent party personnel is exceeded, an additional investment for supply inventory, base support equipment and spares is estimated. An investment cost for travel and training is estimated for any increase in permanent party personnel, with no threshold value involved.

For investment costs that are calculated only when a threshold value has been equaled or exceeded, the increases and decreases in numbers of personnel are cumulated algebraically from the first year until the threshold is equaled. Then initial investment is computed and the cumulated change is set to zero. In computing investment costs based on increases in permanent party personnel, the program automatically excludes the effects of any year-to-year change in allocation percentages.

Interpretation of Major Equipment Investment

When the model shows a requirement for investment in training aircraft, an actual expenditure of funds is seldom indicated. Training aircraft in sufficient numbers to accommodate the student load and to provide attrition replacement are included in the original procurement decision. Thus, when more airplanes are needed, they are usually drawn from the existing Air Force inventory. Moreover, it is unlikely that replacement aircraft could be purchased because, in most cases, production is halted as soon as the originally-established procurement level is met. However, if the model is used for a new weapon system, an investment requirement could mean actual procurement of aircraft for training. If the beginning aircraft inventory were zero, the investment cost of all the airplanes needed for the training program would be included. Aircraft procurement costs are based on average flyaway costs such as those given in AFM 172-3.*

A requirement for investment in simulators or trainers usually involves a transfer of equipment between organizations rather than purchase. Only by a study of the particular circumstances can it be determined whether the investment involves a transfer or a purchase.

The chief value of the computation of major equipment investment is that it may indicate that the capacity of the equipment has been exceeded. Before accepting the investment requirement as valid, all pertinent model inputs should be reviewed.

COSTS EXCLUDED

The reasons why certain costs are omitted from the estimates are briefly explained below.

Facilities Costs

As previously stated (page 7), no provision is made for the inclusion of facilities costs because existing physical plants (buildings, roads, etc.) are regarded as "sunk costs" and because the expectation

*Air Force Manual 172-3, USAF Cost and Planning Factors Manual, 27 October 1967 (Revised).

is that, if additional schools are required, they will be established on existing bases and will occupy previously-constructed buildings.

Command Overhead

No attempt was made to measure command overhead effort for allocation of costs to pilot training because there is no way in which to isolate advanced pilot training from the multiplicity of other missions for which the Air Staff and the commanders and staffs of the major and intermediate commands are responsible. Some few individuals at these headquarters may be directly and exclusively concerned with advanced pilot training but their costs, relatively speaking, would be small and would have little or no measurable effect on the overall cost of APT programs. For these reasons, command overhead is excluded.

Tanker Support

Tanker support costs are excluded from the model because of uncertainty as to the amount, if any, that would be properly chargeable to pilot training. On many refueling flights, some members of the tanker crew receive APT (or proficiency or continuation) training. Recognition of the interdependence of their training with that being given the APT students in the aircraft being refueled, would require that an offset be made, in some indeterminant amount, against the cost of the refueling flight. Furthermore, the extent, if any, to which tanker sorties would be curtailed if pilot training refuelings were reduced or eliminated is unknown. If the tanker flying hour program remained constant, there would be no identifiable incremental costs and, if it were reduced, the question would remain as to what the net cost to pilot training should be. Because of these uncertainties, the concensus was that the inclusion of so tenuous a charge would be of doubtful value.

Spare Parts for Trainers

Consumption of spare parts for trainers is small and the costs are negligible. It, therefore, was decided that the inclusion of these costs would be an unnecessarily-complicating refinement.

CHOICES AFFECTING THE COMPOSITION OF THE MODEL

The remainder of this section consists of explanations of how some issues were resolved and of why some seemingly-arbitrary limitations were set. Because the shape and content of the model were affected by the decisions that were taken and because opinions differ concerning them, an explanation may be helpful to the users of the model.

Fractions Versus Integers

Throughout the computations, the model deals with fractions of people and fractions of aircraft. The justification for retaining fractions of people and equipment in the estimating process is that courses are not separate activities where it would be logical to deal with only integers. Accepting fractional personnel and equipment for cost estimates is consistent with the services of people and equipment being divided between pilot training and other missions.

Proration of Joint Costs (Allocation Fractions)

Joint costs are incurred when pilots and nonpilots receive training during the same flight.

One of the inputs for the model is the percentage of total flying hours (i.e., the portion of joint costs) to be allocated to pilot training for each type of aircraft. The user may choose any allocation fraction that appears appropriate in view of his purpose in using the model. For the many aircraft having no nonpilot crew members, the percentage would obviously be 100 percent; for aircraft carrying mixed crews, the user must make a decision on proration.

The direct flying hour costs involved are for POL, depot maintenance, and material. The proration of flying hours affects personnel costs because aircraft maintenance personnel are estimated on the basis of flying hours. In turn, administrative and support requirements are derived from a total including maintenance people. Thus, proration has significant effects permeating the resource and cost estimates.

Several methods for prorating flying hour costs among crew members were explored. A B-52 bomber crew, for example, consists of six members

including two pilots. Flying hours could be divided equally among the six crew members. This would allocate too little to pilots because they are receiving training for virtually all the time the crew flies while other crew members have periods during a mission when they are not active. Consideration was given to estimating how much a training mission could be shortened if the nonpilot crew members were excluded from a flight. This information could serve as a basis for proration but is not available. Arbitrary weights could be used in preference to charging all flying hour costs to the pilots and none to the nonpilot trainees.

Probably the most generally acceptable method is to prorate flying hours on the basis of the time that each crew member is engaged in training activities during each mission. Rough estimates of such time can be made from the training activities specified in the course syllabus. For an example, see RM-6085-PR (Volume VI) Section VII.

A decision must also be made with respect to the proration of simulator hours whenever pilots and nonpilots are trained together on a single simulator.

The selected allocation fractions are also applied directly to:

a. Simulator maintenance and operating personnel.

b. Simulator maintenance material and services.

c. Investment cost of additional aircraft and simulators.

d. Aircraft recurring investment.

Simulator/Trainer Usage by Non-Students

It was decided to disregard the hours that simulators and trainers are operated for use by school staff members because such usage by nonstudents is limited and the impact on costs would be negligible.

Fixed Costs

The model accepts only variable factors for calculations involving training hours but provides the option of using both fixed and variable elements for calculations of administrative and support personnel. This option is offered even though most users will probably

elect to omit most fixed inputs because of the difficulties and uncertainties inherent in their selection.

Determination of appropriate fixed factors is difficult because the costs and resources attributable to pilot training are intermingled with those required for other purposes. With few exceptions, estimation of the applicable fixed element involves prorating. Support personnel, for example, provide services for the pilot training program as well as for other missions. To charge all support costs to pilot training (or, alternatively, to charge none) would cause a much larger error than some method of proration irrespective of the method of proration.

Identification of the fixed resource requirement for a base, a school or a particular course involves subjective judgment but an acceptable figure can be established. Then, the fixed element can be prorated on the basis of the number of personnel involved in pilot training relative to the number in all other related activities. The determination and proration of fixed cost elements would be relatively easy for a year in which the installation strength distribution (that is, the distribution of personnel by organizational element) is known. Prorations for future years, however, are very difficult to make because the numbers of pilot training personnel and of all related personnel (both supporting and supported) must be forecast. If costs are to be estimated for many weapon systems and for five to ten years, the effort and uncertainty involved in prorating fixed elements each year become so great that most would agree that it is not feasible. Furthermore, if the percentage of fixed elements charged to pilot training were to be recomputed each year, then the fixed element actually is not fixed with respect to pilots but is variable. Even if the pilot program were constant from year to year, the fixed costs charged to pilot training would change as the level of other activities in the related organizations varied.

One alternative is to establish the chargeable fixed elements for the base year and use the same factor for all succeeding years. This method would eliminate the need to forecast personnel levels for activities other than the pilot training program. The use of constant

fixed elements introduces errors into the cost estimates but it is not certain that annually adjusted fixed elements would be more accurate.

Because the elements that are fixed with respect to combined functions become variable with respect to pilot training when prorated anew each year, a third and preferred method is to omit virtually all* fixed elements. Using this approach, fixed elements need not be distinguished from the variable and no projection is required except for personnel in the pilot training program. By omitting fixed elements, some error is introduced into projected cost estimates: if pilot training expands relative to other missions, costs will be overstated. However, there will be no error due to the use of this method if the base population is constant.

The user of the model has the option of including fixed cost factors for calculation of the following four requirements:

1. Supervisors of instructors and their administrative personnel at squadron level.
2. Supervisors of the academic program and their administrative personnel at squadron level.
3. Administrative personnel at wing level.
4. Support personnel.

The factor inputs can be changed each year or zero inputs can be used. Thus, the user can adopt any method he chooses for computation of these four requirements. The simplest approach is to set the fixed inputs at zero and establish average variable relationships such as support personnel as a percentage of all other personnel. Most users will select this method because, as stated above, the computation of a set of prorated fixed resources for a series of years for a number of weapon systems will be found to be an overwhelming task.

Small, arbitrarily-selected fixed inputs are included in the sample model output shown in Figs. 3 through 10 and in the sensitivity examples presented in Section V. They are used only to demonstrate that the model provides for some fixed elements.

---

*Standard/evaluation personnel are input as a fixed number with no variable element.

In summary, the effort required to compute a new proration of the fixed elements each year when the pilot training program changes in size relative to programs other than pilot training does not appear justified for this model in view of its intended use for planning. This applies to virtually all of the fixed costs for which the model accepts inputs as well as to other relationships where no fixed element is provided for even though conceivable.

Course Length

The model had to be designed to accommodate courses which vary widely in duration. Prescribed course lengths vary from one type of aircraft to another. For example, the B-58 bomber CCTS is a 30-week course whereas the EC-47 reconnaissance aircraft calls for only four weeks. For some types of aircraft, there are several courses of varying lengths to allow for differences in mission and the experience of the students. Furthermore, differences in the rate of progress of some students resulted in lengthening or shortening the prescribed training period.*

From a review of all advanced flying training courses for pilots listed in the USAF Formal Schools Catalog (AFM 50-5), it was determined that two course lengths for each type aircraft would cover virtually all situations. In the case of the F-4, where the mission could be either air-to-air or air-to-ground, the four available courses of different durations could be handled by dividing the F-4 pilot trainees into two groups depending on the type of mission for which they were being prepared. The model makes no allowance for the fact that adjustments are made in the training period for some students because it was assumed the extensions and curtailments balance. The syllabus requirement was considered an acceptable average for all students in either the long or short course. Two course lengths are provided because the difference between the long and short courses is too large

---

*No statistics on the frequency or extent of deviations from the prescribed course length are available but persons familiar with pilot training state that adjustments are made for some students.

to make a single average course acceptable. More than two different courses for each type of aircraft would have greatly increased the number of inputs and calculations required with no significant improvement in the model results.

The model places all student pilots who are to be cross-trained from similar type aircraft in the short course and all others in the long course. In general, this reflects the actual Air Force training practice. To the extent that actual practices differ from the model's procedure, it is assumed that the deviations tend to offset each other.

Types of Aircraft

For some weapon systems (KC-135 tanker for example) all the flying training is accomplished in the primary aircraft. For other weapon system courses, students fly in two, three or four different types of aircraft. A fifth type may be used to tow targets.

Provision for five aircraft types could have been included in the model without difficulty but the number of inputs and computations would have been increased substantially. It was concluded, after studying all information available, that the purposes of this model would be served by allowing three aircraft types to be used for a single course.

It was felt that three aircraft types will suffice because differences between primary aircraft and the trainer version may be ignored as far as costs are concerned and because the few hours of target towing time may be treated as primary aircraft hours with no significant effect on the model outputs.

Support Aircraft Maintenance Personnel

The model is designed to capture (and to prorate to pilot training) the flying hour cost of administrative and transport aircraft used in support of the airbase on which the advanced pilot training is conducted. The model does not, however, identify any particular number of aircraft maintenance personnel as being required for the support aircraft maintenance. It was considered that estimating the

number of maintenance personnel required for support aircraft would be an unnecessary refinement. To compute the number required would involve determination of the personnel needed for each of the different types of support aircraft on base and then allocating an appropriate share to pilot training. Omitting these maintenance personnel only slightly understates the total permanent party personnel chargeable to pilot training. The model does provide for the direct flying hours costs for support aircraft that may be computed by using the factors available in AFM 172-3. These factors include the cost of maintenance personnel.

IV. DETAILED DESCRIPTION OF THE MODEL

This section provides a detailed description of the model. All of the equations are presented verbally and in terms of the variable identification numbers (addresses) defined in Figs. 5 through 10. In the equations, the numbers identifying all the inputs and outputs,* the variable "addresses," are written as F(XXX); in the few cases where an actual value appears, such as the number of weeks in a year, the "F" is omitted.

In many cases, throughout the model, computations are duplicated, as, for example, for each type of aircraft. When this occurs, the verbal equations are generalized for each group of duplicate computations but the numerical equations are specific. The following abbreviations are shown to the right of the numerical equations to indicate the specific category.

Long Course	LC
Short Course	SC
Total	T
Aircraft type 1	A1
Aircraft type 2	A2
Aircraft type 3	A3

Aircraft type 1 is always the primary aircraft for which the pilot is being trained.

STUDENTS

Numbers of entering students for each year are input in four categories--students being cross-trained from dissimilar or similar aircraft, students who recently graduated from UPT and students returning to flying duty after a tour at a desk job. All similar aircraft pilots are automatically placed in the short course and the other three in the long course.

---

*Input addresses are numbered 1-145 and 217-219. Output addresses are numbered 146-216 and 220-308.

Total number of entering students per year = number from similar aircraft + number from dissimilar aircraft + number from desk jobs + number from UPT

$$F(151) = F(003) + F(004) + F(005) + F(006)$$

Number of entering students per year in long course = total number entering students per year - number from similar aircraft

$$F(152) = F(151) - F(003)$$

Number of entering students per year in short course = number from similar aircraft

$$F(153) = F(003)$$

Number graduates = (number entering students) (fraction of entering students who graduate)

$$F(154) = F(152) \cdot F(009) \quad \text{L.C.}$$

$$F(155) = F(153) \cdot F(010) \quad \text{S.C.}$$

$$F(156) = F(154) + F(155) \quad \text{T.}$$

The average number of students per year in a course is a value needed for subsequent computations; it must not be confused with other student figures such as student load.

Average number students per year = number entering students + number graduates ÷ 2

$$F(157) = \frac{F(152) + F(154)}{2} \quad \text{L.C.}$$

$$F(158) = \frac{F(153) + F(155)}{2} \quad \text{S.C.}$$

Average student load is the average number of students attending school at all times throughout the year.

Average student load = (average number students per year) (length of course in weeks ÷ 52 weeks)

$$F(159) = F(157)\left[\frac{F(007)}{52}\right] \quad \text{L.C.}$$

$$F(160) = F(158)\left[\frac{F(008)}{52}\right] \quad \text{S.C.}$$

$$F(161) = F(159) + F(160) \quad \text{T.}$$

STUDENT TRAINING HOURS AND INSTRUCTORS

Student flying hours per year are based on the flying hours per student stated in the course syllabus. The syllabus hours are an acceptable estimate of the hours actually flown, assuming that those who fly more than the syllabus requirement are offset by those who fly less.

When estimating total student flying hours, provision must be made for cases in which two or more students fly together on the same aircraft. If two student pilots regularly fly on each training aircraft the aircraft hours flown are only one-half the student hours. Accordingly, the required hours per student are divided by the average number of students on each training sortie to obtain the aircraft flying hours per student.

The aircraft flying hours per student are multiplied by the average number of students per year to yield the total number of student flying hours required. Use of the average number of students per year [F(157), F(158)] instead of the entering or graduating totals provides an appropriate adjustment for student attrition assuming losses are spread evenly over the year. It should be noted that the flying hour total is for a year rather than the course.

Student flying hours = (average number of students per year) (number of hours each student is required to fly ÷ average number of student pilots on a student crew)

$$F(162) = F(157) \left[\frac{F(011)}{F(021)}\right] \quad \text{LC-A1}$$

$$F(163) = F(157) \left[\frac{F(012)}{F(022)}\right] \quad \text{LC-A2}$$

$$F(164) = F(157) \left[\frac{F(013)}{F(023)}\right] \quad \text{LC-A3}$$

$$F(165) = F(158) \left[\frac{F(014)}{F(024)}\right] \quad \text{SC-A1}$$

$$F(166) = F(158) \left[\frac{F(015)}{F(025)}\right] \quad \text{SC-A2}$$

$$F(167) = F(158) \left[\frac{F(016)}{F(026)}\right] \quad \text{SC-A3}$$

$$F(168) = F(162) + F(165) \quad \text{T-A1}$$

$$F(169) = F(163) + F(166) \quad \text{T-A2}$$

$$F(170) = F(164) + F(167) \quad \text{T-A3}$$

The hours an instructor flies with students includes both the hours spent in the same aircraft with students and the time flown with students while the instructor is in a separate lead or tow aircraft. Since flying instructors frequently supervise more than one student on a training sortie, the hours flown by an instructor must be divided by the average number of students he teaches concurrently.

The hours flown by a student will exceed the hours an instructor flies with the student if students fly solo missions and if check rides are given by noninstructor Standardization-Evaluation pilots.

> Instructor flying hours per student = number of hours instructor flies with each student ÷ average number of student pilots on a student crew

$$F(171) = \frac{F(027)}{F(021)} + \frac{F(028)}{F(022)} + \frac{F(029)}{F(023)} \quad LC;\ A1 + A2 + A3$$

$$F(172) = \frac{F(030)}{F(024)} + \frac{F(031)}{F(025)} + \frac{F(032)}{F(026)} \quad SC;\ A1 + A2 + A3$$

Total hours all instructors fly with students per year = (instructor flying hours per student) (average number of students per year)

$$F(173) = F(171) \cdot F(157) \quad LC$$

$$F(174) = F(172) \cdot F(158) \quad SC$$

$$F(175) = F(173) + F(174) \quad T$$

Total flying instructors required = total hours instructors fly with students per year ÷ maximum hours per year an instructor is available to fly with students

$$F(221) = \frac{F(175)}{F(033)}$$

It should be noted that the sum of all flying pilot instructors for all formal advanced pilot training courses does not equal the total USAF requirement for pilot instructors. Not included, for example, are pilot instructors for courses such as commanders familiarization courses, courses for tactical squadron instructor pilots and navigator courses.

Student simulator hours = (average number of students per year) (hours each student is required to spend on a simulator ÷ average number of student pilots that use one simulator at the same time)

$$F(176) = F(157) \left[\frac{F(017)}{F(038)}\right] \quad LC$$

$$F(177) = F(158) \left[\frac{F(018)}{F(038)}\right] \quad SC$$

$$F(178) = F(176) + F(177) \quad T$$

Total simulator instructors required = total student simulator hours ÷ maximum hours per year a simulator instructor is available for simulator supervision

$$F(222) = \frac{F(178)}{F(034)}$$

Student trainer hours = (average number students per year) (number hours each student is required to spend on a trainer)

$$F(179) = F(157) \cdot F(041) \quad LC$$

$$F(180) = F(158) \cdot F(042) \quad SC$$

$$F(181) = F(179) + F(180) \quad T$$

It has been assumed that there will be only one student at a time receiving instruction on an instrument trainer. As a result, the equations for student trainer hours differ from the corresponding equations for flying hours and simulator hours where more than one student may be receiving instruction at the same time.

Total trainer instructors required = total student trainer hours ÷ maximum hours per year of trainer instruction one instructor is expected to supervise

$$F(223) = \frac{F(181)}{F(035)}$$

Ground school classroom hours = (average number of students per year) (minimum number of hours each student is required to attend ground school ÷ average number of student pilots in ground school classroom at one time)

$$F(182) = F(157) \frac{F(019)}{F(039)} \quad LC$$

$$F(183) = F(158) \frac{F(020)}{F(040)} \qquad SC$$

$$F(184) = F(182) + F(183) \qquad T$$

Ground school instruction is frequently provided by two different groups of instructors. Much of the technical description of equipment is provided by ATC Field Training Detachment (FTD) instructors, generally nonrated airmen. The balance is provided by instructors (mainly, officers) assigned to the advanced pilot training school (CCTS,* TTU or RTU).

Ground school classroom hours taught by CCTS instructors = (ground school classroom hours) (fraction of ground school hours taught by CCTS instructors)

$$F(185) = F(182) \cdot F(043) \qquad LC$$

$$F(186) = F(183) \cdot F(044) \qquad SC$$

$$F(187) = F(185) + F(186) \qquad T$$

Ground school classroom hours taught by FTD instructors = ground school classroom hours - ground school classroom hours taught by CCTS instructors

$$F(188) = F(182) - F(185) \qquad LC$$

$$F(189) = F(183) - F(186) \qquad SC$$

$$F(190) = F(188) + F(189) \qquad T$$

Ground school instructors required = ground school classroom hours ÷ maximum ground school hours per year taught by one instructor

*The APT ground school instructors are referred to as "CCTS instructors" to differentiate them from the FTD instructors.

$$F(224) = \frac{F(187)}{F(036)} \quad \text{CCTS}$$

$$F(225) = \frac{F(190)}{F(037)} \quad \text{FTD}$$

Total instructors required = flying + simulator + trainer + ground school CCTS + ground school FTD instructors

$$F(226) = F(221) + F(222) + F(223) + F(224) + F(225)$$

SUPERVISORY AND ADMINISTRATIVE PERSONNEL AT SQUADRON LEVEL

Instructor supervisors plus administrative personnel required at squadron level = fixed number of supervisors/administrators + (variable number of supervisors/administrators per instructor) (total number of instructors required)

$$F(227) = F(063) + F(064) \cdot F(226)$$

The personnel who supervise and administer the academic program maintain student records, monitor the student schedules and, in general, perform functions at squadron level which vary with the number of students.

No. academic program supervisors plus administrative personnel required at squadron level = fixed number of supervisors/administrators + (variable number of supervisors/administrators per student in average student load) (total average student load)

$$F(228) = F(065) + F(066) \cdot F(161)$$

Standardization-Evaluation pilots assess the capability of pilots to perform their flying duties. They evaluate flight instructors, other permanent party pilots and sometimes, but not always, the students. In some courses, the flight instructors perform the Standardization-Evaluation function with respect to students.

The total number of Standardization-Evaluation personnel required by an APT school is an input rather than the result of a computer calculation. Since the major commands are not uniform in their use of Standardization-Evaluation pilots, adoption of a single estimating relationship for all courses is not feasible. The user must input the appropriate number. This number, which commonly ranges from 5 to 10 pilots per wing, plus supervisory/administrative personnel, is not large enough to have a significant effect on the costs per pilot graduate.

Total Standardization-Evaluation personnel required = fixed input for each course

$$F(229) = F(067)$$

Total number operations personnel excluding students = total instructors + total instructor supervisors and administrative personnel at squadron level + total academic program supervisors and administrative personnel at squadron level + total Standardization-Evaluation personnel

$$F(230) = F(226) + F(227) + F(228) + F(229)$$

TOTAL FLYING HOURS

The total flying hours chargeable to the training program before proration includes all hours flown by students in each of the training aircraft used in the program. (The model allows for the use of three different aircraft types.) Instructor hours flown with students in separate aircraft are added to the student flying hours. To avoid double counting, the instructor hours flown with students in the same aircraft are not added to the student hours.

The separate instructor flying hours are identified as "separate instructor" or "lead/tow" flying hours. "Lead" flying hours are those flown by instructors in separate aircraft while supervising students in other aircraft. "Tow" flying hours are those spent towing targets for student gunnery or missile practice. All lead/tow flying hours are assumed to be flown in the primary mission aircraft (Aircraft Type

1 in the model). There are exceptions where lead/tow hours are flown in other than the primary mission aircraft but they may be disregarded as insignificant.

In addition to the student flying hours and the instructor separate lead/tow hours, there are several other categories of flying hours chargeable to an APT program. "Other Flying Hours" includes hours flown by permanent party personnel who are related to the program (instructors, supervisors, administrators and support personnel). Flying hours for the following purposes should be included in "Other Flying Hours:"

a. Proficiency training.
b. Standardization-Evaluation flights.
c. Test and ferry flights.
d. Annual instrument and proficiency checks.
e. Training to qualify as APT instructor pilots.

Flying hours to be excluded are:

a. Special missions directed by higher headquarters and unrelated to APT training.
b. Training by combat ready crews to maintain proficiency for EWO mission.
c. Proficiency requirements fulfilled by flying on a student training mission.

"Other Flying Hours" are estimated as a fraction of total student flying hours combined with instructor separate flying hours. For many courses, there will be no separate (lead/tow) hours. Several test calculations indicate that this fraction will probably vary between .05 and .10.

Total separate instructor flying hours in lead or tow aircraft = (average number of students per year) (instructor flying hours per student in separate lead or tow aircraft)

$$F(215) = F(157) \cdot F(142) \quad \text{LC, A1}$$

$$F(216) = F(158) \cdot F(143) \quad \text{SC, A1}$$

Other flying hours = (total student flying hours + total separate instructor flying hours in lead or tow aircraft) (fraction representing other flying hours charged to crew training)

F(191) = [F(168) + F(215) + F(216)][F(047)] A1

Other flying hours = (total student flying hours) (fraction representing other flying hours charged to crew training)

F(192) = F(169) · F(048) A2

F(193) = F(170) · F(049) A3

Total flying hours = total student flying hours + total separate instructor flying hours in lead or tow aircraft + other flying hours

F(194) = F(168) + F(215) + F(216) + F(191) A1

Total flying hours = total student flying hours + other flying hours

F(195) = F(169) + F(192) A2

F(196) = F(170) + F(193) A3

MAJOR EQUIPMENT REQUIREMENTS

The numbers of aircraft, simulators and instrument trainers required are all computed by the same method. It should be remembered that the user of the model may choose to allocate to pilot training a fraction of the cost of the whole APT program but the numbers of aircraft, simulators and trainers required are not affected by the use of this fraction.

Number of aircraft required = total flying hours required per year ÷ flying hours available per year on one aircraft

$$F(205) = \frac{F(194)}{F(055)} \quad A1$$

$$F(206) = \frac{F(195)}{F(056)} \quad A2$$

$$F(207) = \frac{F(196)}{F(057)} \quad A3$$

Number of simulators required = total student simulator hours required per year ÷ training hours available per year on one simulator

$$F(208) = \frac{F(178)}{F(053)}$$

Number of instrument trainers required = total student trainer hours required per year ÷ training hours available per year on one trainer

$$F(209) = \frac{F(181)}{F(054)}$$

Aircraft lost in peacetime from flying accidents is an element considered in estimating aircraft procurement. An average attrition rate can be obtained for most USAF aircraft from the attrition data in USAF Cost and Planning Factors (AFM 172-3). These rates probably differ from the rates experienced in advanced pilot training; the latter would be preferred if known. The rates are expressed as number of aircraft lost per 100,000 flying hours.

Aircraft attrition = (total flying hours) (aircraft loss per 100,000 flying hours) ÷ 100,000 flying hours

$$F(302) = \frac{F(194) \cdot F(045)}{100,000} \quad A1$$

$$F(303) = \frac{F(195) \cdot F(046)}{100,000} \quad A2$$

$$F(304) = \frac{F(196) \cdot F(144)}{100,000} \quad A3$$

The numbers of aircraft, simulators or instrument trainers to be procured are computed by the same general method except that the attrition element applies only to aircraft. It is assumed that the additional major items of equipment needed are purchased in the year the need arises. If the computation shows that the number to be procured is less than zero, the number is set to zero. In this case, there is no procurement and the inventory is not reduced.

Number of aircraft to be procured in the current year = aircraft required for the current year - aircraft inventory at beginning of current year + aircraft lost due to attrition

$$F(210)_t = F(205)_t - F(200)_{t-1} + F(302)_t \quad A1$$

$$F(211)_t = F(206)_t - F(201)_{t-1} + F(303)_t \quad A2$$

$$F(212)_t = F(207)_t - F(202)_{t-1} + F(304)_t \quad A3$$

(t and t-1 indicate a time difference of one year.)

Number of simulators to be procured in current year = simulators required for current year - simulator inventory at beginning of current year

$$F(213)_t = F(208)_t - F(203)_{t-1}$$

Number of instrument trainers to be procured in current year = trainers required for current year - trainer inventory at beginning of current year

$$F(214)_t = F(209)_t - F(204)_{t-1}$$

The inventory of aircraft, simulators and trainers is updated each year by adding the equipment procured and deducting attrition losses for aircraft. For the first year, the beginning inventory is an input; thereafter the inventory equals the beginning-of-the-year inventory

(preceding year's ending inventory) plus additions, if any, minus attrition.

In time, attrition will erode the aircraft inventory and eventually result in a need for replacement. If the initial inventories are zero, the investment requirement for the first year will cover the cost of all the major equipment.

Current aircraft inventory = inventory at beginning of year + aircraft procured during the year - aircraft losses due to attrition during the year

$$\left.\begin{aligned} F(200)_1 &= F(058) + F(210)_1 - F(302)_1 && \text{1st year} \\ F(200)_t &= F(200)_{t-1} + F(210)_t - F(302)_t && \text{all other years} \end{aligned}\right\} \text{A1}$$

$$\left.\begin{aligned} F(201)_1 &= F(059) + F(211)_1 - F(303)_1 && \text{1st year} \\ F(201)_t &= F(201)_{t-1} + F(211)_t - F(303)_t && \text{all other years} \end{aligned}\right\} \text{A2}$$

$$\left.\begin{aligned} F(202)_1 &= F(060) + F(212)_1 - F(304)_1 && \text{1st year} \\ F(202)_t &= F(202)_{t-1} + F(212)_t - F(304)_t && \text{all other years} \end{aligned}\right\} \text{A3}$$

(t and t-1 indicate a time difference of one year.)

Current simulator inventory = inventory at beginning of year + simulators procured during the year

$$F(203)_1 = F(061) + F(213)_1 \quad \text{1st year}$$

$$F(203)_t = F(203)_{t-1} + F(213)_t \quad \text{all other years}$$

Current trainer inventory = inventory at beginning of year + trainers procured during the year

$$F(204)_1 = F(062) + F(214)_1 \quad \text{1st year}$$

$$F(204)_t = F(204)_{t-1} + F(214)_t \quad \text{all other years}$$

PERSONNEL

The number of aircraft maintenance personnel required is based on flying hours and maintenance man-years per flying hour. The flying hours used may be all flying hours or some fraction thereof.

Flying hours to be charged to pilot training = (total flying hours required for the APT program) (fraction of total flying hours chargeable to pilot training)

$$F(197) = F(194) \cdot F(050) \quad A1$$

$$F(198) = F(195) \cdot F(051) \quad A2$$

$$F(199) = F(196) \cdot F(052) \quad A3$$

Maintenance man-hours per flying hour are converted to man-years for the model, using a standard 40-hour work week.

Number of aircraft maintenance personnel required = (number of flying hours charged to pilot training) (number of aircraft maintenance personnel required per flying hour)

$$F(231) = F(197) \cdot F(068) \quad A1$$

$$F(232) = F(198) \cdot F(069) \quad A2$$

$$F(233) = F(199) \cdot F(070) \quad A3$$

$$F(234) = F(231) + F(232) + F(233) \quad T$$

Personnel authorized for maintenance and operation of simulators (not simulator instructors) may be calculated as so many per simulator. An alternative method calculates the required personnel on the basis of hours the simulator is used. The computer obtains the required number of personnel by either method, automatically choosing the appropriate method on the basis of the size of the input factor. If the first method is adopted (man-years per simulator) the factor will be

one or more. If the second method is adopted (man-years per hour) the factor will be less than one. Both calculation methods reflect the user's decision as to whether all or only part of the hours and costs should be charged to pilot training.

Simulator hours charged to pilot training = (total student simulator hours) (fraction of student simulator hours allocated to pilot training)

$$F(220) = F(178) \cdot F(135)$$

Simulator maintenance and operating personnel = (number of simulators required) (simulator maintenance and operating personnel per simulator) (fraction of simulator hours allocated to pilot training)

$$F(235) = F(208) \cdot F(071) \cdot F(135) \quad \text{if} \quad F(071) \geq 1$$

or

Simulator maintenance and operating personnel = (simulator hours charged to pilot training) (simulator maintenance and operating personnel per simulator hour)

$$F(235) = F(220) \cdot F(071) \quad \text{if} \quad F(071) < 1$$

Trainer maintenance and operating personnel = (current trainer inventory) (trainer maintenance and operating personnel per trainer)

$$F(236) = F(204) \cdot F(072)$$

The model does not include an alternative computation method for trainers because the available information did not show that trainer hours were used as the basis for personnel authorizations.

Total simulator and trainer maintenance and operating personnel = simulator maintenance and operating personnel + trainer maintenance and operating personnel

$$F(237) = F(235) + F(236)$$

Total number of maintenance and operations personnel = total operations personnel excluding students + total aircraft maintenance personnel + total simulator and trainer maintenance and operating personnel

$$F(238) = F(230) + F(234) + F(237)$$

Administrative personnel at wing level are treated as a function of maintenance and operations personnel.

Total administrative personnel at wing level = fixed number of administrative personnel at wing level + (variable number of wing level administrative personnel per maintenance and operations personnel) (total number of maintenance and operations personnel)

$$F(239) = F(073) + F(074) \cdot F(238)$$

Total student load plus operations, maintenance and administrative personnel = student load + total maintenance and operations personnel + total administrative personnel at wing level

$$F(240) = F(161) + F(238) + F(239)$$

The number of support personnel chargeable to pilot training is a function of student load and the operations, maintenance and administrative personnel.

Total support personnel = fixed number of support personnel + (variable number of support personnel per person included in total of operations, maintenance and administrative personnel plus student load) (student load plus operations, maintenance and administrative personnel)

$$F(241) = F(075) + F(076) \cdot F(240)$$

Total personnel charged to pilot training including student load = total student load plus operations, maintenance and administrative personnel + total support personnel

$$F(242) = F(240) + F(241)$$

Total permanent party personnel = total personnel charged to pilot training including student load - student load

$$F(243) = F(242) - F(161)$$

The various categories making up permanent party personnel are subdivided into officers, airmen and civilians; officers are further classified as rated or nonrated. Some categories (flight instructors, for example) are normally composed entirely of officers. The mixed categories are subdivided by multiplying by the fractions who are officers or airmen; civilians are obtained as residuals. Officers are classified as rated or nonrated by applying another fraction.

Total permanent party officers = categories consisting of officers only + (various mixed personnel categories) (fraction of category who are officers)

$$\begin{aligned} F(244) = {} & F(221) + F(222) + F(223) + F(229) + F(224) \cdot F(077) \\ & + F(225) \cdot F(079) + F(227) \cdot F(081) + F(228) \cdot F(083) \\ & + F(234) \cdot F(085) + F(237) \cdot F(087) + F(239) \cdot F(089) \\ & + F(241) \cdot F(091) \end{aligned}$$

Total permanent party airmen = (various mixed personnel categories) (fraction of category who are airmen)

$$\begin{aligned} F(245) = {} & F(224) \cdot F(078) + F(225) \cdot F(080) + F(227) \cdot F(082) \\ & + F(228) \cdot F(084) + F(234) \cdot F(086) + F(237) \cdot F(088) \\ & + F(239) \cdot F(090) + F(241) \cdot F(092) \end{aligned}$$

Total permanent party military personnel = permanent party officers + permanent party airmen

$$F(246) = F(244) + F(245)$$

Total permanent party civilians = permanent party personnel - permanent party military personnel

$$F(247) = F(243) - F(246)$$

Total permanent party rated officers = (total permanent party officers) (fraction who are rated in personnel categories which include both rated and nonrated officers) + (categories which include only rated officers) (1 - fraction who are rated in personnel categories which include both rated and nonrated officers)

$$F(248) = F(244) \cdot F(093) + [F(221) + F(222) + F(223) + F(229)][1 - F(093)]$$

Total permanent party nonrated officers = total permanent party officers - total permanent party rated officers

$$F(249) = F(244) - F(248)$$

Change in student load = student load in current year - student load in previous year

$$F(250)_t = F(161)_t - F(161)_{t-1}$$

Change in permanent party personnel and student load combined = total personnel charged to pilot training including student load for current year - total number personnel charged to pilot training including student load for preceding year

$$F(251)_t = F(242)_t - F(242)_{t-1}$$

Change in permanent party personnel before adjustment = total permanent party personnel for current year - total permanent party personnel for preceding year

$$F(252)_t = F(243)_t - F(243)_{t-1}$$

Change in permanent party military personnel = total permanent party military personnel for current year - total permanent party military personnel for preceding year

$$F(253)_t = F(246)_t - F(246)_{t-1}$$

INVESTMENT COSTS

An additional investment for training equipment and spares might be computed for each unit increase in the student load. However, to preclude unrealistic increases in investment for small increases in the student load, the user of the computer program may input a threshold so that no increase in investment will be computed until the threshold is equaled or exceeded. A decrease in student load will not cause disinvestment. As student loads vary, the computer calculates the change in student load each year and accumulates the changes until the sum of the increases and decreases equals or exceeds the threshold. Then the entire net increase is used to compute the new initial investment in training equipment and spares. The accumulated student load change is then set to zero and the process begins again.

Cumulative change in student load = sum of all increases and decreases in student load since the threshold was equaled or exceeded

$$F(256) = \Sigma F(250)$$

Cumulate until $F(256) \geq F(094)$

Initial investment for training equipment and spares for student load increase = (cumulative change in student load) (initial investment cost for training equipment and spares per increase in student load) (factor converting costs to thousands of dollars)

$$F(267) = F(256) \cdot F(101) \cdot (.001)$$

Computed when $F(256) \geq F(094)$

Changes in permanent party personnel involve a similar but more complicated problem. The following four categories of initial investment cost may be affected by increases in permanent party personnel:

a. Base support equipment and spares - F(268).

b. Supply inventory - F(269).

c. Training - F(270).

d. Travel (PCS) - F(271).

An increase in permanent party personnel will affect the computation of initial investment for each of these four items. The procedure applying to the first two items is similar to that described above for increases in student loads. The annual changes (plus and minus) are accumulated until the net increase equals or exceeds a threshold which the user considers substantial enough to warrant computation of an increment in investment. After the initial investment is computed, the accumulated change is set to zero and accumulation begins again.

Training and travel are treated differently from base support equipment and spares and supply inventory. Any increase in permanent party personnel results in a cost for training and travel because there is no accumulation of changes and no threshold. It is assumed that every increase will involve the costs of bringing people to the base and of training them for their duties. This training would be off-base in courses such as Air Training Command technical training courses. Decreases in permanent party strength are ignored so far as training and travel investments are concerned.

In the computation of investment costs, an increase in permanent party personnel must be adjusted to eliminate any part of the change that is due solely to a variation in an allocation fraction. Adjustment is necessary because increase or decrease in personnel due to a change in an allocation fraction could result in an invalid investment requirement.

The allocation fractions for aircraft and simulators will almost always remain constant for a particular weapon system during a computer run. There are exceptions, however. For example, a modification of a crew training program, such as changing a two-pilot crew to one pilot and a navigator, would call for a change in the allocation fraction. It is also possible that the user of the model may wish to experiment by varying the allocation fraction from year to year during one computer run.

When an allocation fraction is changed, the training hours attributed to pilots are changed and this, in turn, affects many other output variables including the number of permanent party personnel. The number of people needed to support the crew training program is not altered because the allocation fraction is varied. The only change is in the number charged to pilot training. If no real increase in the total number of people has occurred, there is no need for more investment for equipment, supplies, training or PCS travel. More resources and costs are charged to pilot training, but no increment in investment is needed. Therefore, when the model computes the incremental investment based on increases in permanent party personnel, it excludes the effect due solely to variation in an allocation fraction.

When an allocation fraction is varied, the required adjustment in permanent party personnel is computed by means of the following equation:

$$
\begin{aligned}
F(255) = & \Big\{ [1 + F(074)][1 + F(076)] \Big\} \\
& \Big\{ [F(050)_t - F(050)_{t-1}][F(068)][F(194)] \\
& + [F(051)_t - F(051)_{t-1}][F(069)][F(195)] \\
& + [F(052)_t - F(052)_{t-1}][F(070)][F(196)] \\
& + [F(135)_t - F(135)_{t-1}][F(071)][F(178)] \Big\}
\end{aligned}
$$

When $F(071) \geq 1$, F(208) is substituted for F(178). The derivation of this equation is shown in the Appendix.

Permanent party change adjusted for change in allocation fraction = change in number of permanent party personnel - adjustment

$$F(254) = F(252) - F(255)$$

Cumulative change in permanent party personnel = sum of annual changes adjusted to eliminate effect of changes in allocation fraction

$$F(257) = \Sigma F(254)$$

Cumulation continues until the threshold is equaled or exceeded, that is until $F(257) \geq F(122)$. Then $F(257)$ is used to compute initial investment. Thereafter it is set to zero and cumulation begins again.

Initial investment for base support equipment and spares for permanent party increase = (cumulative change in permanent party personnel adjusted for change in allocation fraction) (initial investment cost for base support equipment and spares per permanent party increase) (factor converting costs to thousands of dollars)

$$F(268) = F(257) \cdot F(123) \cdot (.001)$$

Computed when $F(257) \geq F(122)$

Initial investment for base supply inventory for permanent party increase = (cumulative change in permanent party personnel adjusted for change in allocation fraction) (initial investment cost for base supply inventory per permanent party increase) (factor converting costs to thousands of dollars)

$$F(269) = F(257) \cdot F(124) \cdot (.001)$$

Computed when $F(257) \geq F(122)$

Initial investment cost for training for permanent party increase = (annual increase in permanent party personnel adjusted for change in allocation fraction) (initial investment cost for off-base training per permanent party increase) (factor converting costs to thousands of dollars)

$$F(270) = F(254) \cdot F(125) \cdot (.001)$$

Compute only if $F(254) > 0$

Initial investment cost for PCS travel for permanent party increase = (annual increase in permanent party personnel adjusted for change in allocation fraction) (initial investment cost for travel per permanent party increase) (factor converting costs to thousands of dollars)

$$F(271) = F(254) \cdot F(126) \cdot (.001)$$

Compute only if $F(254) > 0$

Initial investment for aircraft to be procured = (number of aircraft to be procured) (cost per aircraft) (fraction of cost allocated to pilot training)

$$F(258) = F(210) \cdot F(095) \cdot F(050) \quad \text{A1}$$

$$F(259) = F(211) \cdot F(096) \cdot F(051) \quad \text{A2}$$

$$F(260) = F(212) \cdot F(097) \cdot F(052) \quad \text{A3}$$

Initial investment for simulators to be procured = (number of simulators to be procured) (cost per simulator) (fraction of cost allocated to pilot training)

$$F(261) = F(213) \cdot F(098) \cdot F(135)$$

Initial investment for trainers to be procured = (number of trainers to be procured) (cost per trainer)

$$F(262) = F(214) \cdot F(099)$$

Initial investment for aircraft spares = (initial investment for aircraft to be procured) (fraction of initial investment in aircraft for aircraft spares cost)

$$F(263) = F(258) \cdot F(140) \quad A1$$

$$F(264) = F(259) \cdot F(140) \quad A2$$

$$F(265) = F(260) \cdot F(140) \quad A3$$

Initial investment for simulator spares = (initial investment for simulators to be procured) (fraction of initial investment in simulators for simulator spares cost)

$$F(266) = F(261) \cdot F(100)$$

Investment for trainer spares has not been included in the model because the amount appeared to be relatively small and not worthwhile.

Total initial investment cost =

$$F(272) = F(258) + F(259) + F(260) + F(261) + F(262) + F(263) + F(264) + F(265) + F(266) + F(267) + F(268) + F(269) + F(270) + F(271)$$

OPERATING COSTS

Depot maintenance operating cost = (flying hours charged to pilot training by type aircraft) (depot maintenance operating cost per flying hour by type aircraft) (factor converting costs to thousands of dollars)

$$F(273) = [F(197) \cdot F(102) + F(198) \cdot F(103) + F(199) \cdot F(104)][.001]$$

POL operating cost = (flying hours charged to pilot training by type aircraft) (POL operating cost per flying hour by type aircraft) (factor converting costs to thousands of dollars)

$$F(274) = [F(197) \cdot F(105) + F(198) \cdot F(106) + F(199) \cdot F(107)][.001]$$

Material operating cost related to flying hours = (flying hours charged to pilot training by type aircraft) (material operating cost per flying hour by type aircraft) (factor converting costs to thousands of dollars)

$$F(275) = [F(197) \cdot F(108) + F(198) \cdot F(109) + F(199) \cdot F(110)][.001]$$

Total direct flying hour operating costs = depot maintenance operating cost + POL operating cost + material operating cost

$$F(276) = F(273) + F(274) + F(275)$$

Munitions operating cost = (average number of students per year) (students' munitions operating cost per student) (factor converting costs to thousands of dollars)

$$F(277) = F(157) \cdot F(111) \cdot (.001) \quad \text{LC}$$

$$F(278) = F(158) \cdot F(112) \cdot (.001) \quad \text{SC}$$

Operating cost for pay for particular category = (number of persons in category) (average pay for particular category) (factor converting costs to thousands of dollars)

Students	$F(279) = F(161) \cdot F(127) \cdot (.001)$
Officers-rated	$F(280) = F(248) \cdot F(128) \cdot (.001)$
Officers-nonrated	$F(281) = F(249) \cdot F(129) \cdot (.001)$
Airmen	$F(282) = F(245) \cdot F(130) \cdot (.001)$
Civilians	$F(285) = F(247) \cdot F(131) \cdot (.001)$

Total operating cost for permanent party military pay

$$F(283) = F(280) + F(281) + F(282)$$

Total operating cost for military pay for permanent party personnel plus students

$$F(284) = F(279) + F(283)$$

Total operating cost for pay

$$F(286) = F(284) + F(285)$$

Operating cost for student travel, either TDY or PCS = (total number of entering students per year) (operating cost per student for travel) (factor converting costs to thousands of dollars)

$$F(287) = F(151) \cdot F(113) \cdot (.001)$$

Operating cost for TDY of permanent party personnel = (total permanent party personnel charged to pilot training) (average operating cost per year for permanent party personnel TDY) (factor converting costs to thousands of dollars)

$$F(288) = F(243) \cdot F(132) \cdot (.001)$$

"All other services" includes all base operating costs not covered elsewhere. It includes costs for utilities, transportation of things, contractual services, laundry, etc.

Operating cost for all other services = (total number of persons charged to pilot training including student load) (average annual operating cost per person on the base for all other services) (factor converting costs to thousands of dollars)

$$F(289) = F(242) \cdot F(133) \cdot (.001)$$

"Other supplies and equipment" includes all supplies and equipment not otherwise covered, that is, all except the material directly related to flying hours, munitions and simulator/trainer material.

Operating cost for other supplies and equipment = (total number of persons charged to pilot training including student load) (average annual operating cost per person on the base for other supplies and equipment) (factor converting costs to thousands of dollars)

$$F(290) = F(242) \cdot F(134) \cdot (.001)$$

There is very little recorded information regarding the costs of material and services for the maintenance of simulators and trainers. Although the available documentation indicates that the costs are relatively low, they are included in the model because of the current interest in cost savings that would be attained if more simulator hours were substituted for the expensive flying hours.

Simulator maintenance material and services = (simulators required) (annual operating cost per simulator for maintenance material and services) (fraction of simulator cost allocated to pilot training)

$$F(291) = F(208) \cdot F(114) \cdot F(135)$$

Trainer maintenance material and services = (current trainer inventory) (annual operating cost per trainer for maintenance material and services)

$$F(292) = F(204) \cdot F(145)$$

Sometimes it is necessary to rent an area where pilots can practice gunnery. The model provides for annual target rent as a throughput wherever this cost is incurred.

Annual target rent = annual target rent

$$F(293) = F(115)$$

A few support aircraft are usually available on a base for the transportation of people and things. All personnel on a base benefit

directly or indirectly from the services of these aircraft. The annual cost is normally not great and, therefore, an elaborate estimating procedure does not seem justified. Accordingly, the annual cost divided by the number of people on the base yields a factor for the model. The costs intended to be included are the direct costs per flying hour--POL, depot maintenance and base maintenance. It has been assumed that this cost factor is a constant for all courses but the user may vary it for each course if desired.

Support aircraft flying hour cost = (total personnel charged to pilot training including students) (operating cost for support aircraft per person on base) (factor converting costs to thousands of dollars)

$$F(294) = F(242) \cdot F(136)(.001)$$

The model recognizes that there is a continuing training program for permanent party officers and airmen in off-base courses conducted by Air Training Command and Air University. The training on-base is not estimated separately but is covered by the total operating costs.

Officers off-base training cost = (total permanent party officers) (operating cost for permanent party officers off-base training per officer) (factor converting costs to thousands of dollars)

$$F(295) = F(244) \cdot F(137)(.001)$$

Airman off-base training cost = (total permanent party airmen) (operating cost for permanent party airmen off-base training per airman) (factor converting costs to thousands of dollars)

$$F(296) = F(245) \cdot F(138) \cdot (.001)$$

Permanent change of station (PCS) cost for permanent party personnel is estimated separately, that is, apart from the student TDY/PCS cost. This cost is estimated on the basis of an average PCS cost per person rather than per move. If the cost per move were used, a second

estimate would be required for the number of moves. For demonstration purposes, the annual PCS cost at a typical base was divided by the number of persons on base, excluding tenants who funded their own PCS costs.

Operating cost for permanent change of station = (total permanent party personnel) (operating cost per year for PCS per permanent party personnel) (factor converting costs to thousands of dollars)

$$F(297) = F(243) \cdot F(139) \cdot (.001)$$

As previously stated, "recurring investment" for aircraft is the cost of modifications plus spares, common age plus spares and component improvement. It is estimated annually as a fraction of average aircraft cost. It is sometimes classified as "investment;" sometimes as "operating cost." In this model it is included in operating costs.

Recurring investment = (number of aircraft required) (initial investment cost per aircraft) (recurring investment cost as fraction of aircraft cost) (fraction of cost allocated to pilot training)

$$F(305) = F(205) \cdot F(095) \cdot F(217) \cdot F(050) \qquad \text{A1}$$

$$F(306) = F(206) \cdot F(096) \cdot F(218) \cdot F(051) \qquad \text{A2}$$

$$F(307) = F(207) \cdot F(097) \cdot F(219) \cdot F(052) \qquad \text{A3}$$

$$F(308) = F(305) + F(306) + F(307) \qquad \text{T}$$

Total other operating costs = sum 14 elements of operating cost

$$F(298) = F(277) + F(278) + F(287) + F(288) + F(289) + F(290) + F(291) + F(292) + F(293) + F(294) + F(295) + F(296) + F(297) + F(308)$$

Total operating cost = (operating cost based on flying hours) + (operating cost for pay of military and civilian personnel) + (other operating cost)

$$F(299) = F(276) + F(286) + F(298)$$

Operating cost per graduate = (total operating cost) (factor converting costs to dollars) ÷ (total number of graduates)

$$F(300) = \frac{F(299) \cdot (1000)}{F(156)}$$

Total system cost excluding R&D = total operating cost + total increase in initial investment cost

$$F(301) = F(299) + F(272)$$

Research and Development costs may be included in the model as throughputs by weapon system. Since the R&D throughput [F(116)] is not used in any computations within the model, no output address number is needed. R&D cost is shown in the printout as the last item following the last year for each weapon system run.

SAMPLE OUTPUTS

To illustrate how the APT computer program can be used, a set of inputs for a bomber aircraft has been developed. These inputs approximate the actual current experience. They have been used to illustrate the kind of output obtainable and the effects of changing selected inputs.

Figures 3 through 10 show for one weapon system (bomber aircraft) and for one year the form in which the computer outputs are printed. Results for any number of years and for any number of aircraft systems can be presented in this form from a single computer run.

Of the 155 possible output values, 14 have been selected as being of general interest and they are always printed for each year and weapon system in the form shown in Fig. 3. All of the input and output values

ADVANCED PILOT TRAINING COST MODEL TEST RUN NO. 1

PAGE 1

WEAPON SYSTEM A

(ALL OUTPUT COSTS EXCEPT OPERATING COST PER GRADUATE ARE IN THOUSANDS OF DOLLARS.)

YEAR	NO. GRAD	AVG STUD. LOAD	PERM PARTY PERS	NO. TYPE 1 ACFT REQ	NO. TYPE 2 ACFT REQ	NO. TYPE 3 ACFT REQ	NO. SIMS REQ	INV COST	FLYING HOUR COST	PAY	OTHER OPER COST	TOTAL OPER COST	OPER PLUS INV COST	OPER COST PER GRAD ($)
1967	396	107	1206	29.08	0.0	0.0	1.72	0	11761	8763	5953	26477	26477	66861

Fig. 3--Sample Output: Standard Printout

WEAPON SYSTEM A
(ALL OUTPUT COSTS EXCEPT OPERATING COST PER GRADUATE ARE IN THOUSANDS OF DOLLARS.)

PAGE 2

COMMON DUMP

1	2	3	4	5	6	7	8	9	10	ADDRESSES
1.000	1.000	200.000	40.000	60.000	100.000	14.000	14.000	0.990	0.990	1- 10
103.000	0.0	0.0	103.000	0.0	0.0	27.000	27.000	188.000	188.000	11- 20
2.000	0.0	0.0	2.000	0.0	0.0	85.000	0.0	0.0	85.000	21- 30
0.0	0.0	425.000	600.000	600.000	300.000	300.000	2.000	16.000	16.000	31- 40
6.000	6.000	0.700	0.700	1.100	0.0	0.050	0.0	0.0	0.460	41- 50
0.0	0.0	3120.000	2600.000	740.000	0.0	0.0	30.000	0.0	0.0	51- 60
3.000	2.000	2.000	0.125	3.000	0.100	8.000	0.050	0.0	0.0	61- 70
0.012	2.000	5.000	0.140	0.0	0.550	1.000	0.0	0.100	0.900	71- 80
0.500	0.500	0.240	0.740	0.020	0.960	0.200	0.800	0.210	0.750	81- 90
0.060	0.710	0.750	20.000	6500.000	0.0	0.0	900.000	80.000	0.050	91- 100
100.000	650.000	0.0	0.0	371.000	0.0	0.0	167.000	0.0	0.0	101- 110
10.000	10.000	500.000	8.000	0.0	0.0	1.000	0.0	0.0	1.000	111- 120
1967.000	100.000	500.000	800.000	1000.000	400.000	10543.000	16000.000	13500.000	4800.000	121- 130
6763.000	25.000	407.000	810.000	0.700	15.000	250.000	150.000	446.000	0.150	131- 140
1.000	0.0	0.0	0.0	2.000	2.000	1.000	1.000	1.000	1967.000	141- 150
400.000	200.000	200.000	198.000	198.000	396.000	199.000	199.000	53.577	53.577	151- 160
107.154	10248.492	0.0	0.0	10248.492	0.0	0.0	20496.984	0.0	0.0	161- 170
42.500	42.500	8457.492	8457.492	16914.984	2686.498	2686.498	5372.996	1193.999	1193.999	171- 180
2387.999	2338.249	2338.249	4676.496	1636.774	1636.774	3273.548	701.475	701.475	1402.949	181- 190
1024.849	0.0	0.0	21521.832	0.0	0.0	9900.039	0.0	0.0	29.763	191- 200
0.0	0.0	3.000	2.000	29.084	0.0	0.0	1.722	0.918	0.0	201- 210
0.0	0.0	0.0	0.0	0.0	0.0	0.039	0.0	0.0	3761.097	211- 220
39.800	8.955	3.980	10.912	4.676	68.323	10.540	13.715	8.000	100.579	221- 230
495.002	0.0	0.0	495.002	45.133	4.000	49.133	644.714	95.260	847.127	231- 240
465.920	1313.047	1205.893	148.363	936.384	1084.746	121.146	126.456	21.907	0.0	241- 250
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	251- 260
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	261- 270
0.0	0.0	6435.023	3672.914	1653.306	11761.238	1.990	1.990	1129.722	2023.291	271- 280
295.743	4494.641	6813.672	7943.391	819.313	8762.703	200.000	30.147	534.410	1063.567	281- 290
9.644	4.000	0.0	19.696	37.091	140.458	537.828	5953.117	26477.059	66861.250	291- 300
26477.059	0.237	0.0	0.0	3372.299	0.0	0.0	3372.299	0.0	0.0	301- 310

Fig. 4--Sample Output: Common Dump

NOTE: Input addresses are numbered 1-145 and 217-219. Output addresses are numbered 146-216 and 220-308. If an input or output title on the listing shown in Figs. 5-10 is followed by a dollar ($) sign, it is stated in dollars; if there is no dollar sign, cost is stated in thousands of dollars.

WEAPON SYSTEM A
(ALL OUTPUT COSTS EXCEPT OPERATING COST PER GRADUATE ARE IN THOUSANDS OF DOLLARS.)

PAGE 3

1	WEAPON SYSTEM NUMBER	1.00000
2	YEAR NUMBER (1., 2., 3., . . . ETC.)	1.00000
3	ENTERING STUDENTS FROM SIMILAR AIRCRAFT	200.00000
4	ENTERING STUDENTS FROM DISSIMILAR AIRCRAFT	40.00000
5	ENTERING STUDENTS FROM DESK JOBS	60.00000
6	ENTERING STUDENTS FROM UNDERGRADUATE PILOT TRAINING (UPT)	100.00000
7	LENGTH OF LONG COURSE (WEEKS)	14.00000
8	LENGTH OF SHORT COURSE (WEEKS)	14.00000
9	FRACTION OF ENTERING STUDENTS WHO GRADUATE--LONG COURSE	0.95000
10	FRACTION OF ENTERING STUDENTS WHO GRADUATE--SHORT COURSE	0.99000
11	HOURS EACH STUDENT REQUIRED TO FLY--TYPE 1 AIRCRAFT, LONG COURSE	103.00000
12	HOURS EACH STUDENT REQUIRED TO FLY--TYPE 2 AIRCRAFT, LONG COURSE	0.0
13	HOURS EACH STUDENT REQUIRED TO FLY--TYPE 3 AIRCRAFT, LONG COURSE	0.0
14	HOURS EACH STUDENT REQUIRED TO FLY--TYPE 1, SHORT COURSE	103.00000
15	HOURS EACH STUDENT REQUIRED TO FLY--TYPE 2, SHORT COURSE	0.0
16	HOURS EACH STUDENT REQUIRED TO FLY--TYPE 3, SHORT COURSE	0.0
17	SIMULATOR HOURS REQUIRED PER STUDENT--LONG COURSE	27.00000
18	SIMULATOR HOURS REQUIRED PER STUDENT--SHORT COURSE	27.00000
19	HOURS STUDENT REQUIRED TO ATTEND GROUND SCHOOL (GS)--LONG COURSE	188.00000
20	HOURS STUDENT REQUIRED TO ATTEND GROUND SCHOOL (GS)--SHORT COURSE	188.00000
21	AVERAGE NO. STUDENT PILOTS ON STUDENT CREW--TYPE 1, LONG COURSE	2.00000
22	AVERAGE NO. STUDENT PILOTS ON STUDENT CREW--TYPE 2, LONG COURSE	0.0
23	AVERAGE NO. STUDENT PILOTS ON STUDENT CREW--TYPE 3, LONG COURSE	0.0
24	AVERAGE NO. STUDENT PILOTS ON STUDENT CREW--TYPE 1, SHORT COURSE	2.00000
25	AVERAGE NO. STUDENT PILOTS ON STUDENT CREW--TYPE 2, SHORT COURSE	0.0
26	AVERAGE NO. STUDENT PILOTS ON STUDENT CREW--TYPE 3, SHORT COURSE	0.0
27	HOURS INSTRUCTOR FLIES WITH EACH STUDENT--TYPE 1, LONG COURSE	85.00000
28	HOURS INSTRUCTOR FLIES WITH EACH STUDENT--TYPE 2, LONG COURSE	0.0
29	HOURS INSTRUCTOR FLIES WITH EACH STUDENT--TYPE 3, LONG COURSE	0.0
30	HOURS INSTRUCTOR FLIES WITH EACH STUDENT--TYPE 1, SHORT COURSE	85.00000
31	HOURS INSTRUCTOR FLIES WITH EACH STUDENT--TYPE 2, SHORT COURSE	0.0
32	HOURS INSTRUCTOR FLIES WITH EACH STUDENT--TYPE 3, SHORT COURSE	0.0
33	MAXIMUM HOURS PER YEAR INSTRUCTOR FLIES WITH STUDENTS	425.00000
34	MAXIMUM SIMULATOR HOURS PER YEAR INSTRUCTOR SUPERVISES	600.00000
35	MAXIMUM TRAINER HOURS PER YEAR INSTRUCTOR SUPERVISES	600.00000
36	MAXIMUM GS HOURS PER YEAR CCTS INSTRUCTOR TEACHES	300.00000
37	MAXIMUM GS HOURS PER YEAR FTD INSTRUCTOR TEACHES	300.00000
38	AVG NO. STUDENT PILOTS ON SIMULATOR AT ONE TIME	2.00000
39	AVG NO. STUDENT PILOTS IN GS CLASSROOM AT ONE TIME--LONG COURSE	16.00000
40	AVG NO. STUDENT PILOTS IN GS CLASSROOM AT ONE TIME--SHORT COURSE	16.00000
41	TRAINER HOURS REQUIRED PER STUDENT--LONG COURSE	6.00000
42	TRAINER HOURS REQUIRED PER STUDENT--SHORT COURSE	6.00000
43	FRACTION OF GS HOURS TAUGHT BY CCTS INSTRUCTORS--LONG COURSE	0.70000
44	FRACTION OF GS HOURS TAUGHT BY CCTS INSTRUCTORS--SHORT COURSE	0.70000
45	AIRCRAFT ATTRITION PER 100000 FLYING HOURS--TYPE 1	1.10000
46	AIRCRAFT ATTRITION PER 100000 FLYING HOURS--TYPE 2 (SEE 144)	0.0
47	OTHER FH CHARGED TO CREW TRNG (FRACT. STUD.+SEP. INST. FH)--TYPE 1	0.05000
48	OTHER FH CHARGED TO CREW TRAINING (FRACTION STUDENT FH)--TYPE 2	0.0
49	OTHER FH CHARGED TO CREW TRAINING (FRACTION STUDENT FH)--TYPE 3	0.0
50	FRACTION OF TOTAL FH OR COST ALLOCATED TO PILOT TRAINING--TYPE 1	0.46000
51	FRACTION OF TOTAL FH OR COST ALLOCATED TO PILOT TRAINING--TYPE 2	0.0
52	FRACTION OF TOTAL FH OR COST ALLOCATED TO PILOT TRAINING--TYPE 3	0.0
53	TRAINING HOURS AVAILABLE PER YEAR ON ONE SIMULATOR	3120.00000

NOTE: If an input or output title is followed by a dollar sign ($), it is stated in dollars; if there is no dollar sign, cost is stated in thousands of dollars.

Fig. 5--Sample Output: Variable Listing, F(001) - F(053)

WEAPON SYSTEM A (ALL OUTPUT COSTS EXCEPT OPERATING COST PER GRADUATE ARE IN THOUSANDS OF DOLLARS.)

PAGE 4

54	TRAINING HOURS AVAILABLE PER YEAR ON ONE TRAINER	2600.00000
55	AVAILABLE FLYING HOURS PER YEAR--TYPE 1	740.00000
56	AVAILABLE FLYING HOURS PER YEAR--TYPE 2	0.0
57	AVAILABLE FLYING HOURS PER YEAR--TYPE 3	0.0
58	AIRCRAFT AVAILABLE AT BEGINNING OF FIRST YEAR--TYPE 1	30.00000
59	AIRCRAFT AVAILABLE AT BEGINNING OF FIRST YEAR--TYPE 2	0.0
60	AIRCRAFT AVAILABLE AT BEGINNING OF FIRST YEAR--TYPE 3	0.0
61	SIMULATORS AVAILABLE AT BEGINNING OF FIRST YEAR	3.00000
62	TRAINERS AVAILABLE AT BEGINNING OF FIRST YEAR	2.00000
63	FIXED NUMBER OF INSTRUCTOR-SUPERV+ADMIN--SQDN LEVEL	2.00000
64	VARIABLE NUMBER OF INSTRUCTOR-SUPERV+ADMIN (PER INST.)--SQDN LEVEL	0.12500
65	FIXED NUMBER OF ACADEMIC-PROGRAM SUPERVISORS--SQUADRON LEVEL	3.00000
66	VARIABLE NO. ACAD-PROG SUPERV. PER STUD. IN STUD. LOAD--SQDN LEVEL	0.10000
67	TOTAL STANDARD-EVALUATION PERSONNEL REQUIRED	8.00000
68	AIRCRAFT MAINTENANCE PERSONNEL REQUIRED PER FLYING HOUR--TYPE 1	0.05000
69	AIRCRAFT MAINTENANCE PERSONNEL REQUIRED PER FLYING HOUR--TYPE 2	0.0
70	AIRCRAFT MAINTENANCE PERSONNEL REQUIRED PER FLYING HOUR--TYPE 3	0.0
71	SIMULATOR OPER+MTC PERS AUTHORIZED PER SIMULATOR OR PER SIM HOUR	0.01200
72	TRAINER OPER+MTC PERS AUTHORIZED PER TRAINER	2.00000
73	FIXED NUMBER OF ADMINISTRATIVE PERSONNEL--WING LEVEL	5.00000
74	VARIABLE NO. ADMIN PERS--WING LEVEL (PER OPER+MTC PERSONNEL)	0.14000
75	FIXED NUMBER OF SUPPORT PERSONNEL	0.0
76	VARIABLE NO. SUPPORT PERS (PER TOTAL STUDENT LOAD+OPER+MTC+ADMIN)	0.55000
77	FRACTION OF GS CCTS INSTRUCTORS WHO ARE OFFICERS	1.00000
78	FRACTION OF GS CCTS INSTRUCTORS WHO ARE AIRMEN	0.0
79	FRACTION OF GS FTD INSTRUCTORS WHO ARE OFFICERS	0.10000
80	FRACTION OF GS FTD INSTRUCTORS WHO ARE AIRMEN	0.50000
81	FRACTION OF INSTRUCTOR-SUPERV+ADMIN (SQDN LEVEL) WHO ARE OFFICERS	0.50000
82	FRACTION OF INSTRUCTOR-SUPERV+ADMIN (SQDN LEVEL) WHO ARE AIRMEN	0.50000
83	FRACTION OF ACAD-PROGRM SUPERV+ADMIN (SQDN LEVEL) WHO ARE OFFICERS	0.24000
84	FRACTION OF ACAD-PROGRM SUPERV+ADMIN (SQDN LEVEL) WHO ARE AIRMEN	0.74000
85	FRACTION OF AIRCRAFT MTC PERSONNEL WHO ARE OFFICERS	0.02000
86	FRACTION OF AIRCRAFT MTC PERSONNEL WHO ARE AIRMEN	0.56000
87	FRACTION OF SIMULATOR AND TRAINER MTC+OPER PERS WHO ARE OFFICERS	0.20000
88	FRACTION OF SIMULATOR AND TRAINER MTC+OPER PERS WHO ARE AIRMEN	0.80000
89	FRACTION OF ADMIN PERSONNEL (WING LEVEL) WHO ARE OFFICERS	0.21000
90	FRACTION OF ADMIN PERSONNEL (WING LEVEL) WHO ARE AIRMEN	0.75000
91	FRACTION OF SUPPORT PERSONNEL WHO ARE OFFICERS	0.06000
92	FRACTION OF SUPPORT PERSONNEL WHO ARE AIRMEN	0.71000
93	FRACTION OF OFFICERS WHO ARE RATED	0.75000
94	MIN INCREASE IN STUDENT LOAD BEFORE I.I. TRNG EQUIP+SPARES JUSTIF.	20.00000
95	I.I. COST PER AIRCRAFT--TYPE 1	6500.00000
96	I.I. COST PER AIRCRAFT--TYPE 2	0.0
97	I.I. COST PER AIRCRAFT--TYPE 3	0.0
98	I.I. COST PER SIMULATOR	900.00000
99	I.I. COST PER TRAINER	80.00000
100	FRACTION OF I.I. SIMULATOR COST FOR SIMULATOR SPARES COST	0.05000
101	I.I. COST FOR TRNG EQUIP+SPARES PER INCREASE IN STUDENT LOAD ($)	100.00000
102	OPERATING COST PER FLYING HOUR FOR DEPOT MTC--TYPE 1 ($)	650.00000
103	OPERATING COST PER FLYING HOUR FOR DEPOT MTC--TYPE 2 ($)	0.0
104	OPERATING COST PER FLYING HOUR FOR DEPOT MTC--TYPE 3 ($)	0.0
105	OPERATING COST PER FLYING HOUR FOR POL--TYPE 1 ($)	371.00000
106	OPERATING COST PER FLYING HOUR FOR POL--TYPE 2 ($)	0.0

Fig. 6--Sample Output: Variable Listing, F(054) - F(106)

WEAPON SYSTEM A PAGE 5
(ALL OUTPUT COSTS EXCEPT OPERATING COST PER GRADUATE ARE IN THOUSANDS OF DOLLARS.)

107	OPERATING COST PER FLYING HOUR FOR POL--TYPE 3 ($)	0.0
108	OPERATING COST PER FLYING HOUR FOR MATERIAL--TYPE 1 ($)	167.00000
109	OPERATING COST PER FLYING HOUR FOR MATERIAL--TYPE 2 ($)	0.0
110	OPERATING COST PER FLYING HOUR FOR MATERIAL--TYPE 3 ($)	0.0
111	OPERATING COST PER STUDENT FOR MUNITIONS--LONG COURSE ($)	10.00000
112	OPERATING COST PER STUDENT FOR MUNITIONS--SHORT COURSE ($)	10.00000
113	OPERATING COST PER STUDENT FOR AVERAGE TDY/PCS ($)	500.00000
114	OPERATING COST PER SIM PER YR FOR SIM MTC--MATERIAL, SERVICES	8.00000
115	OPERATING COST PER YEAR FOR TARGET RENTAL	0.0
116	R AND D COST	0.0
117	DUMP PRINTOUT DESIGNATOR (0./1.--DO NOT/DO PRINT DUMP)	1.00000
118	ZERO-OUTPUT DESIGNATOR (0./1.--DO NOT/DO ZERO OUTPUT EXCEPT GRADS)	0.0
119	CLEAR DESIGNATOR (0./1.--DO NOT/DO ZERO OUT ALL F VARIABLES	0.0
120	WEAPON SYSTEM VARIABLE-LISTING PRINT DESIGNATOR	1.00000
121	BEGINNING YEAR (E.G., 1969)	1967.00000
122	MIN INCREASE IN PERM PARTY BEFORE I.I. EQUIP+SUPPLIES JUSTIFIED	100.00000
123	I.I. COST FOR BASE SUPPORT EQUIP+SPARES PER PERM PARTY INCREASE($)	500.00000
124	I.I. COST FOR BASE SUPPLY INVENTORY PER PERM PARTY INCREASE ($)	800.00000
125	I.I. COST FOR PERM-PARTY-INCREASE TRAINING OFF BASE ($)	1000.00000
126	I.I. COST FOR PERM-PARTY-INCREASE TRAVEL ($)	400.00000
127	OPER. COST PER YEAR FOR AVG PAY OF STUDENT ($)	10543.00000
128	OPER. COST PER YEAR FOR AVG PAY OF PERM PARTY RATED OFFICER ($)	16000.00000
129	OPER. COST PER YEAR FOR AVG PAY OF PERM PARTY NONRATED OFFICER ($)	13500.00000
130	OPER. COST PER YEAR FOR AVG PAY OF PERM PARTY AIRMAN ($)	4800.00000
131	OPER. COST PER YEAR FOR AVG PAY OF CIVILIAN ($)	6763.00000
132	OPER. COST PER YEAR FOR AVG TDY OF PERM PARTY ($)	25.00000
133	OPER. COST PER YEAR FOR SERVICES--AVG PER PERSON ON BASE ($)	407.00000
134	OPER. COST PER YEAR FOR SUPPLIES+EQUIP PER PERSON ON BASE ($)	810.00000
135	FRACTION OF SIMULATOR HOURS OR COSTS ALLOCATED TO PILOT TRAINING	0.70000
136	OPER. COST PER YEAR FOR SUPPORT ACFT--AVG PER PERSON ON BASE ($)	15.00000
137	OPER. COST PER YEAR FOR PERM PARTY OFFICER TRAINING OFF BASE ($)	250.00000
138	OPER. COST PER YEAR FOR PERM PARTY AIRMAN TRAINING OFF BASE ($)	150.00000
139	OPER. COST PER YEAR FOR AVERAGE PCS PER PERM PARTY PERSON ($)	446.00000
140	FRACTION OF I.I. AIRCRAFT COST FOR AIRCRAFT SPARES COST	0.15000
141	VARIABLE-LISTING READ DESIGNATOR (0./1.--DO NOT/DO READ VARIABLES)	1.00000
142	INSTRUCTOR LEAD/TOW FLYING HOURS PER STUDENT--TYPE 1, LONG COURSE	0.0
143	INSTRUCTOR LEAD/TOW FLYING HOURS PER STUDENT--TYPE 1, SHORT COURSE	0.0
144	AIRCRAFT ATTRITION PER 100000 FLYING HOURS--TYPE 3 (SEE 045, 046)	0.0
145	OPER. COST PER YEAR FOR TRAINER MTC PER TRNR--MATERIAL, SERVICES	2.00000
146	PAGE NUMBER	2.00000
147	YEAR COUNTER	1.00000
148	END-OF-DATA DESIGNATOR	1.00000
149	PASS COUNTER	1.00000
150	CURRENT YEAR	1967.00000
151	TOTAL ENTERING STUDENTS	400.00000
152	TOTAL ENTERING STUDENTS--LONG COURSE	200.00000
153	TOTAL ENTERING STUDENTS--SHORT COURSE	200.00000
154	TOTAL GRADUATES--LONG COURSE	197.99998
155	TOTAL GRADUATES--SHORT COURSE	197.99998
156	TOTAL GRADUATES	395.99976
157	AVERAGE NUMBER OF STUDENTS PER YEAR--LONG COURSE	198.99988
158	AVERAGE NUMBER OF STUDENTS PER YEAR--SHORT COURSE	198.99988
159	AVERAGE STUDENT LOAD FOR LONG COURSE	53.57689

Fig. 7--Sample Output: Variable Listing, F(107) - F(159)

WEAPON SYSTEM A

(ALL OUTPUT COSTS EXCEPT OPERATING COST PER GRADUATE ARE IN THOUSANDS OF DOLLARS.)

160	AVERAGE STUDENT LOAD FOR SHORT COURSE	53.57689
161	TOTAL AVERAGE STUDENT LOAD	107.15378
162	TOTAL STUDENT FLYING HOURS--TYPE 1, LONG COURSE	10248.49219
163	TOTAL STUDENT FLYING HOURS--TYPE 2, LONG COURSE	0.0
164	TOTAL STUDENT FLYING HOURS--TYPE 3, LONG COURSE	0.0
165	TOTAL STUDENT FLYING HOURS--TYPE 1, SHORT COURSE	10248.49219
166	TOTAL STUDENT FLYING HOURS--TYPE 2, SHORT COURSE	0.0
167	TOTAL STUDENT FLYING HOURS--TYPE 3, SHORT COURSE	0.0
168	TOTAL STUDENT FLYING HOURS--TYPE 1	20496.98438
169	TOTAL STUDENT FLYING HOURS--TYPE 2	0.0
170	TOTAL STUDENT FLYING HOURS--TYPE 3	0.0
171	INSTRUCTOR FH PER STUDENT--ALL AIRCRAFT TYPES, LONG COURSE	42.50000
172	INSTRUCTOR FH PER STUDENT--ALL AIRCRAFT TYPES, SHORT COURSE	42.50000
173	TOTAL HOURS INSTRUCTOR FLIES WITH STUDENTS--LONG COURSE	8457.49219
174	TOTAL HOURS INSTRUCTOR FLIES WITH STUDENTS--SHORT COURSE	8457.49219
175	TOTAL HOURS INSTRUCTOR FLIES WITH STUDENTS	16914.98438
176	TOTAL STUDENT SIMULATOR HOURS--LONG COURSE	2686.49805
177	TOTAL STUDENT SIMULATOR HOURS--SHORT COURSE	2686.49805
178	TOTAL STUDENT SIMULATOR HOURS	5372.99609
179	TOTAL STUDENT TRAINER HOURS--LONG COURSE	1193.99927
180	TOTAL STUDENT TRAINER HOURS--SHORT COURSE	1193.99927
181	TOTAL STUDENT TRAINER HOURS	2387.99854
182	TOTAL GROUND-SCHOOL CLASSROOM HOURS--LONG COURSE	2338.24854
183	TOTAL GROUND-SCHOOL CLASSROOM HOURS--SHORT COURSE	2338.24854
184	TOTAL GROUND-SCHOOL CLASSROOM HOURS	4676.49609
185	TOTAL GS CLASSROOM HOURS TAUGHT BY CCTS INSTRUCTORS--LONG COURSE	1636.77393
186	TOTAL GS CLASSROOM HOURS TAUGHT BY CCTS INSTRUCTORS--SHORT COURSE	1636.77393
187	TOTAL GS CLASSROOM HOURS TAUGHT BY CCTS INSTRUCTORS	3273.54785
188	TOTAL GS CLASSROOM HOURS TAUGHT BY FTD INSTRUCTORS--LONG COURSE	701.47461
189	TOTAL GS CLASSROOM HOURS TAUGHT BY FTD INSTRUCTORS--SHORT COURSE	701.47461
190	TOTAL GS CLASSROOM HOURS TAUGHT BY FTD INSTRUCTORS	1402.94922
191	OTHER FLYING HOURS--TYPE 1	1024.64512
192	OTHER FLYING HOURS--TYPE 2	0.0
193	OTHER FLYING HOURS--TYPE 3	0.0
194	TOTAL FLYING HOURS--TYPE 1	21521.83203
195	TOTAL FLYING HOURS--TYPE 2	0.0
196	TOTAL FLYING HOURS--TYPE 3	0.0
197	FLYING HOURS CHARGED TO PILOT TRAINING--TYPE 1	9900.03906
198	FLYING HOURS CHARGED TO PILOT TRAINING--TYPE 2	0.0
199	FLYING HOURS CHARGED TO PILOT TRAINING--TYPE 3	0.0
200	CURRENT INVENTORY--TYPE 1	29.76326
201	CURRENT INVENTORY--TYPE 2	0.0
202	CURRENT INVENTORY--TYPE 3	0.0
203	CURRENT INVENTORY--SIMULATORS	3.00000
204	CURRENT INVENTORY--TRAINERS	2.00000
205	AIRCRAFT REQUIRED--TYPE 1	29.08354
206	AIRCRAFT REQUIRED--TYPE 2	0.0
207	AIRCRAFT REQUIRED--TYPE 3	0.0
208	SIMULATORS REQUIRED	1.72211
209	TRAINERS REQUIRED	0.91846
210	AIRCRAFT TO BE PROCURED--TYPE 1	0.0
211	AIRCRAFT TO BE PROCURED--TYPE 2	0.0
212	AIRCRAFT TO BE PROCURED--TYPE 3	0.0

Fig. 8--Sample Output: Variable Listing, F(160) - F(212)

WEAPON SYSTEM A
(ALL OUTPUT COSTS EXCEPT CPERATING COST PER GRADUATE ARE IN THOUSANDS OF DOLLARS.)

213	SIMULATORS TO BF PROCURED	0.C
214	TRAINERS TO BE PROCURED	0.0
215	TOTAL INSTRUCTOR LEAD/TOW FLYING HOURS--TYPE 1, LCNG COURSE	0.0
216	TOTAL INSTRUCTOR LEAD/TOW FLYING HOURS--TYPE 1, SHORT COURSE	C.C
217	RECURRING INVESTMENT CCST FACTOR--TYPE 1 (WEAPCN SYSTEM INPUT)	0.03878
218	RECURRING INVESTMENT COST FACTOR--TYPE 2 (WEAPCN SYSTEM INPUT)	C.C
219	RECURRING INVESTMENT COST FACTOR--TYPE 3 (WEAPON SYSTEM INPUT)	C.C
220	SIMULATOR HOURS CHARGED TO PILOT TRAINING	3761.C9717
221	TOTAL FLYING INSTRUCTCRS REQUIRED	39.75556
222	TOTAL SIMULATOR INSTRUCTORS REQUIRED	8.95499
223	TOTAL TRAINER INSTRUCTORS REQUIRED	3.58COC
224	TOTAL GROUND-SCHOOL CCTS INSTRUCTORS REQUIRED	10.91183
225	TOTAL GROUND-SCHOOL FTD INSTRUCTORS REQUIRED	4.67650
226	TOTAL INSTRUCTORS REQUIRED	68.32324
227	TOTAL INSTRUCTOR SUPERVISORS AND ADMIN PERS REQUIRED--SQDN LEVEL	1C.54041
228	TOTAL ACAD-PROGRAM SUPERVISORS AND ADMIN PERS REQUIRED--SQDN LEVEL	13.71537
229	TOTAL STANDARD-EVALUATION PERSONNEL REQUIRED	8.0000C
230	TOTAL NONSTUDENT OPERATIONS PERSONNEL	100.57901
231	TOTAL AIRCRAFT MAINTENANCE PERSCNNEL--TYPE 1	495.CC171
232	TOTAL AIRCRAFT MAINTENANCE PERSCNNEL--TYPE 2	0.C
233	TOTAL AIRCRAFT MAINTENANCE PERSCNNEL--TYPE 3	0.C
234	TOTAL AIRCRAFT MAINTENANCE PERSONNEL	495.CC171
235	TOTAL SIMULATOR MAINTENANCE AND OPERATING PERSONNEL	45.13315
236	TOTAL TRAINER MAINTENANCE AND OPERATING PERSONNEL	4.C000C
237	TOTAL SIMULATOR AND TRAINER MAINTENANCE AND OPERATING PERSONNEL	49.13315
238	TOTAL OPERATIONS AND MAINTENANCE PERSONNEL	644.71362
239	TOTAL ADMINISTRATIVE PERSONNEL (WING LEVEL)	95.25985
240	TOTAL STUDENT LOAD + OPERATIONS + MTC + ADMINISTRATIVE PERSONNEL	847.12695
241	TOTAL SUPPORT PERSONNEL	465.51968
242	TOTAL PERSONNEL CHARGED TO PILOT TRAINING, INCLUDING STUDENTS	1313.04663
243	TOTAL PERMANENT PARTY PERSONNEL	1205.89282
244	TOTAL PERMANENT PARTY OFFICERS	148.36266
245	TOTAL PERMANENT PARTY AIRMEN	936.38379
246	TOTAL PERMANENT PARTY MILITARY PERSONNEL	1084.74634
247	TOTAL CIVILIANS	121.14649
248	TOTAL PERMANENT PARTY RATED OFFICERS	126.45572
249	TOTAL PERMANENT PARTY NONRATED OFFICERS	21.9C694
250	CHANGE IN STUDENT LOAD	0.0
251	CHANGE IN TOTAL PERSONNEL, INCLUDING STUDENTS	0.C
252	CHANGE IN TOTAL PERMANENT PARTY PERSONNEL	0.0
253	CHANGE IN TOTAL PERMANENT PARTY MILITARY PERSCNNEL	0.C
254	CHANGE IN PERM. PARTY LESS CHANGE DUE TO ALLOC. FRACTION VARIATION	0.0
255	ADJUSTMENT TO FLIM. EFFECT ON I.I. COST OF CHANGE IN ALLOC. FRACT.	0.C
256	CUMULATIVE CHANGE IN STUDENT LOAD UNTIL THRESHOLD IS REACHED	0.0
257	CUMULATIVE CHANGE IN ADJ. PERM PARTY UNTIL THRESHOLD IS REACHED	0.0
258	I.I. COST OF AIRCRAFT TO BE PROCURED--TYPE 1	0.C
259	I.I. COST OF AIRCRAFT TO BE PROCURED--TYPE 2	0.C
260	I.I. COST OF AIRCRAFT TO BF PROCURED--TYPE 3	0.C
261	I.I. COST OF SIMULATORS TO BE PROCURED	0.0
262	I.I. COST OF TRAINERS TO BE PROCURED	0.C
263	I.I. COST OF AIRCRAFT SPARES--TYPE 1	0.C
264	I.I. COST OF AIRCRAFT SPARES--TYPE 2	0.0
265	I.I. COST OF AIRCRAFT SPARES--TYPE 3	0.C

Fig. 9--Sample Output: Variable Listing, F(213) - F(265)

WEAPON SYSTEM A PAGE 8

(ALL OUTPUT COSTS EXCEPT OPERATING COST PER GRADUATE ARE IN THOUSANDS OF DOLLARS.)

266	I.I. COST OF SIMULATOR SPARES	0.0
267	I.I. COST OF TRAINING EQUIP AND SPARES FOR STUDENT LOAD INCREASE	0.0
268	I.I. COST OF BASE SUPPORT EQUIP+SPARES FOR PERM PARTY INCREASE	0.0
269	I.I. COST OF SUPPLIES FOR PERMANENT PARTY INCREASE	0.0
270	I.I. COST OF TRAINING FOR PERMANENT PARTY INCREASE	0.0
271	I.I. COST OF TRAVEL FOR PERMANENT PARTY INCREASE (PCS)	0.0
272	TOTAL INCREASE IN I.I. COST	0.0
273	OPERATING COST OF DEPOT MAINTENANCE	6435.02344
274	OPERATING COST OF POL	3672.91357
275	OPERATING COST OF MATERIAL	1653.30566
276	OPERATING COST OF TOTAL FLYING HOURS	11761.23828
277	OPERATING COST OF MUNITIONS--LONG COURSE	1.99000
278	OPERATING COST OF MUNITIONS--SHORT COURSE	1.99000
279	OPERATING COST OF STUDENT PAY	1129.72168
280	OPERATING COST OF RATED OFFICER PAY	2023.29077
281	OPERATING COST OF NONRATED OFFICER PAY	295.74341
282	OPERATING COST OF AIRMEN PAY	4494.64063
283	OPERATING COST OF TOTAL PERMANENT PARTY MILITARY PAY	6813.67188
284	OPERATING COST OF TOTAL MILITARY PAY, INCLUDING STUDENTS	7943.39063
285	OPERATING COST OF CIVILIAN PAY	819.31348
286	OPERATING COST OF TOTAL PAY--MILITARY PLUS CIVILIANS	8762.70313
287	OPERATING COST OF STUDENT TDY/PCS	199.99998
288	OPERATING COST OF ALL PERMANENT PARTY PERSONNEL TDY	30.14731
289	OPERATING COST OF SERVICES	534.40967
290	OPERATING COST OF SUPPLIES AND EQUIPMENT	1063.56689
291	OPERATING COST OF SIMULATOR MTC, MATERIAL, AND SERVICES	9.64384
292	OPERATING COST OF TRAINER MTC, MATERIAL, AND SERVICES	4.00000
293	OPERATING COST OF TARGET RENTAL	0.0
294	OPERATING COST OF SUPPORT AIRCRAFT	19.69569
295	OPERATING COST OF OFFICERS TRAINING	37.09065
296	OPERATING COST OF AIRMEN TRAINING	140.45755
297	OPERATING COST OF PERMANENT CHANGE OF STATION	537.82813
298	TOTAL OTHER OPERATING COST, INCLUDING RECURRING INVESTMENT	5953.11719
299	TOTAL OPERATING COST, INCLUDING RECURRING INVESTMENT	26477.05859
300	OPERATING COST PER GRADUATE ($)	66861.25000
301	TOTAL SYSTEM COST (INVESTMENT + OPERATING), EXCLUDING R AND C	26477.05859
302	AIRCRAFT LOST TO ATTRITION--TYPE 1	0.23674
303	AIRCRAFT LOST TO ATTRITION--TYPE 2	0.0
304	AIRCRAFT LOST TO ATTRITION--TYPE 3	0.0
305	RECURRING INVESTMENT COST (OPERATING COST)--TYPE 1	3372.29932
306	RECURRING INVESTMENT COST (OPERATING COST)--TYPE 2	0.0
307	RECURRING INVESTMENT COST (OPERATING COST)--TYPE 3	0.0
308	TOTAL AIRCRAFT RECURRING INVESTMENT COST (OPERATING COST)	3372.29932
309	NOT USED	0.0
310	NOT USED	0.0

Fig. 10--Sample Output: Variable Listing, F(266) - F(310)

for any year and weapon system may be printed at the option of the user in the form shown in Fig. 4. In this form, referred to as the "common dump," the values are identified by address number only. Also, the user may have any number of selected variables printed as in Figs. 5 through 10. In this form, the variables are identified both by address number and by title. For other examples of the model printout see RM-6087-PR.

Neither the inputs nor the outputs in Figs. 3 through 10 are to be considered as the results of completed research. Where official factors were readily available, they were used but, in many cases, crude estimates were developed or arbitrary assumptions made. The purpose was to demonstrate how the computer program operates and not to make accurate usable estimates.

V. SENSITIVITY ANALYSIS

This model has been designed primarily for estimating costs for long-range planning but it may also be used to explore the effects of variations in selected inputs. To show how the model may be used for sensitivity analysis a few base case inputs have been varied to reveal their relative impact on costs. At the same time, these examples may contribute to a greater understanding of the underlying characteristics of the model. The four examples presented cover variations in (1) number of students, (2) flying and simulator hours, (3) fraction of entering students who graduate and (4) flight instructor workload. The base case variables used in these examples are the inputs and outputs shown in the sample format for Weapon System A, Figs. 3 through 10.

It must be remembered that the specific numerical results of these examples are developed only for demonstration purposes.

VARIATION IN NUMBER OF ENTERING STUDENTS

Starting with the base case, a series of computer runs were made with all inputs remaining constant except the number of entering students.

Figure 11 shows total operating cost as a linear function of the number of entering students. Based on the inputs used for this example, the fixed costs of $404,079 are relatively small and the variable cost per student is $65,183. The marginal operating cost per entering student is constant; it would be greater but still be constant if graduates or student load were substituted for entering students.

The curved line in Fig. 11 shows the average operating cost per graduate. Moving from left to right, the curve decreases rapidly when the number of graduates is small and then slowly declines toward a limit equal to the marginal cost per graduate.

For reasons given in the explanation of fixed costs (commencing on page 20 of this draft), only minor fixed costs have been included in the base case. Because fixed costs are small, a 20 percent increase in the number of entering students (from 400 to 480) results

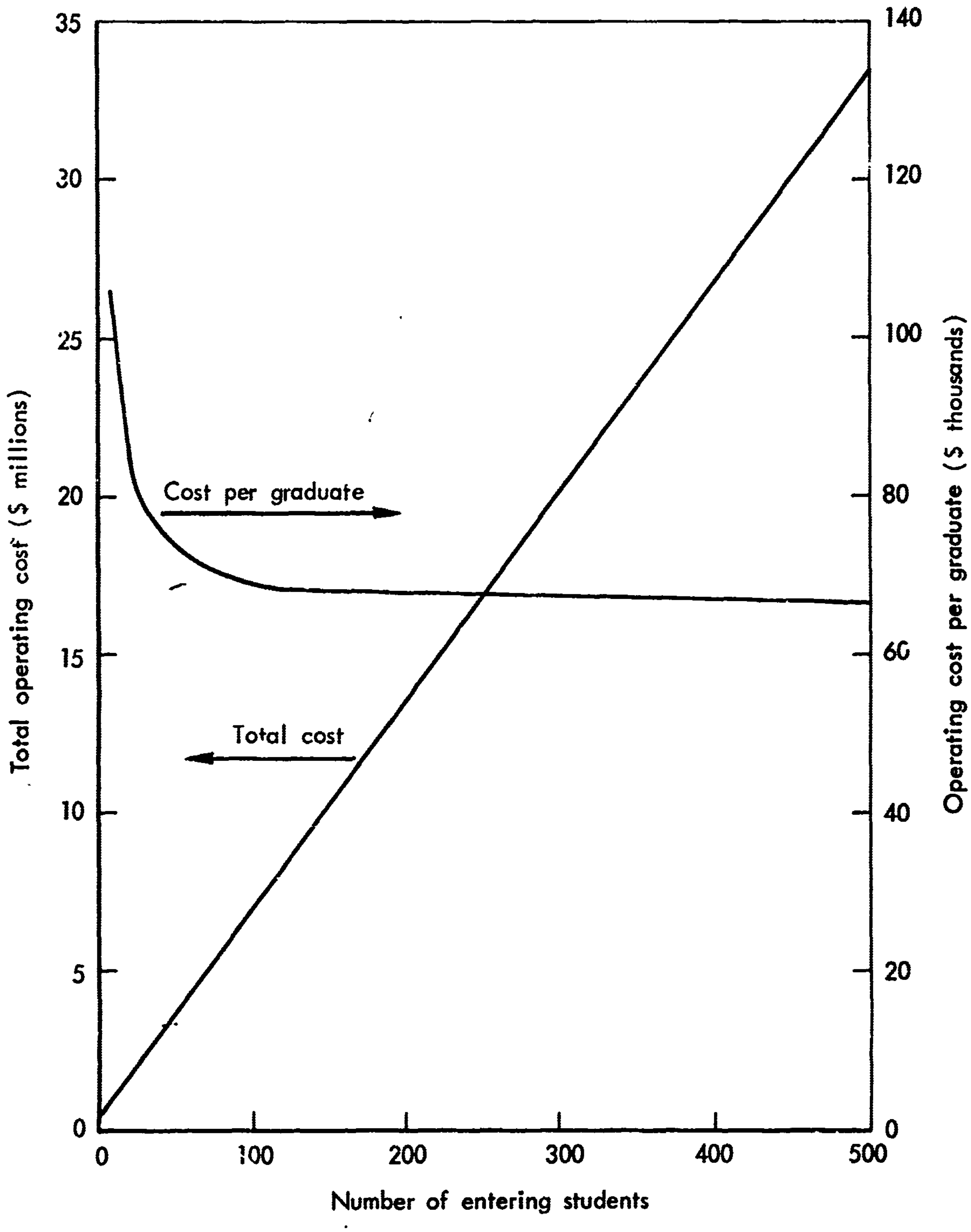


Fig. 11--Sensitivity Analysis, Weapon System A: Total Operating Cost and Operating Cost Per Graduate vs. Number of Entering Students

in a nearly proportional increase in total costs (19.69 percent) and an insignificant decrease in operating cost per graduate (1/4 of 1 percent). If the fixed costs were relatively larger, total operating cost would be less sensitive and operating cost per graduate would be more sensitive to changes in the number of entering students.

The computer is programmed to assign entering students to the long or short course depending on the students' experience. Students from similar aircraft are placed in the short course and all others in the long course. When an APT program has only one course, the students are still divided into long and short course groups but, since the inputs are the same for both courses, the costs are not affected by the distribution of students between the courses.

In situations involving two courses of different lengths and requirements, there is a different linear relationship between cost and students for each course. Combining the students from the two courses will yield a single linear relationship if the percentage distribution of students between courses remains constant; or, the percentage change in number of students must be the same for each course if the combined function is to yield a straight line.

When the number of entering students varies there will be related changes in graduates, permanent party personnel and student load. In each case, the relationship is linear for the long and short courses treated separately. When the students in the two courses are combined, the changes in number of students for each course must be of equal proportions and in the same direction to maintain a linear relationship.

The effect of changes in number of students on investment is more complicated than on operating costs. In general, an increase in student numbers will require additional investment but the amount in any one year may be large or small depending on a number of factors. If aircraft, simulators and trainers were not being used to capacity, more students could be trained without procuring additional major items of equipment. Furthermore, for investment categories that are functions of numbers of people, additional investment does not occur until the specified thresholds are equaled or exceeded. If the number of students decreases, there is no negative investment but, for some

investment categories, no addition is called for until the decrease is offset by an increase. Finally, even if the student level remains constant, aircraft attrition due to peacetime losses will eventually erode the inventory so that additional aircraft will be required. These factors realistically cause annual new investment to be irregular even though the number of students is related to investment in a linear fashion.

The underlying student-investment relationship established by the base case inputs can be brought out by some unrealistic constraints. By setting the aircraft, simulator and trainer inventories for the first year exactly equal to the number required, the effect of any excess capacity is avoided. Setting the investment thresholds at zero allows a student increase to be effective immediately no matter how small the change.

If it is assumed that the number of students does not decrease at any time and that all students are in one course using one type of training aircraft, the following equation describes the relation between number of entering students and the additional investment required for any year.

$$I = SK_a + \Delta SK_I$$

I = the additional investment cost for the current year

S = the number of entering students for the current year

ΔS = the increase in number of entering students above the corresponding number for the preceding year

K_a = the constant annual investment per entering student required to offset aircraft attrition

K_I = the constant additional investment required per additional entering student for all other investment categories.

Values for K_a and K_I for the base case are \$2035 and \$260,975 respectively.

This equation demonstrates that, in this model, investment as a function of students is composed of two elements: a recurring element

reflecting aircraft attrition and a second composite element depending on increases in the number of students.

In summary, the marginal cost per student is constant for a given set of inputs for a single APT course. Costs reflecting aircraft attrition accrue by a constant amount per student each year and will in time appear as a requirement for additional investment. New investment per additional student is a fixed one-time cost for a given set of inputs. Investment costs, determined by the model for a particular year, depend on the thresholds and excess capacity.

VARIATION IN FLYING AND SIMULATOR HOURS

Pilot training methods are currently being studied with the purpose of improving the graduates' flying capabilities and reducing the cost. One possibility for moving toward this goal is to substitute simulator training for some flying hours. The APT cost model can be used to estimate the cost effects of alternate combinations of flying hours and simulator hours.

Starting with the base case, for example, simulator hours can be substituted for flying hours on an arbitrarily selected two for one ratio. Reduction in flying hours necessitates another change in input; that is, for consistency, the number of hours the instructors fly with students should be correspondingly reduced.

As expected, the substitution of simulator training for flying training brings a large reduction in operating costs. The horizontal scale of Fig. 12 represents the student flying hours replaced by simulator hours; the hours which instructors fly with students is reduced by an equal amount. For each flying hour subtracted, two simulator hours were added.

As Fig. 12 shows, the relationship is linear. Based on the inputs used in this example, the operating cost per graduate is decreased $560 for each hour subtracted from the flying hours required per student. Each hour added to the simulator hours required per student increases operating cost per graduate by $86. Thus, for each flying hour replaced by two simulator hours, operating cost per graduate

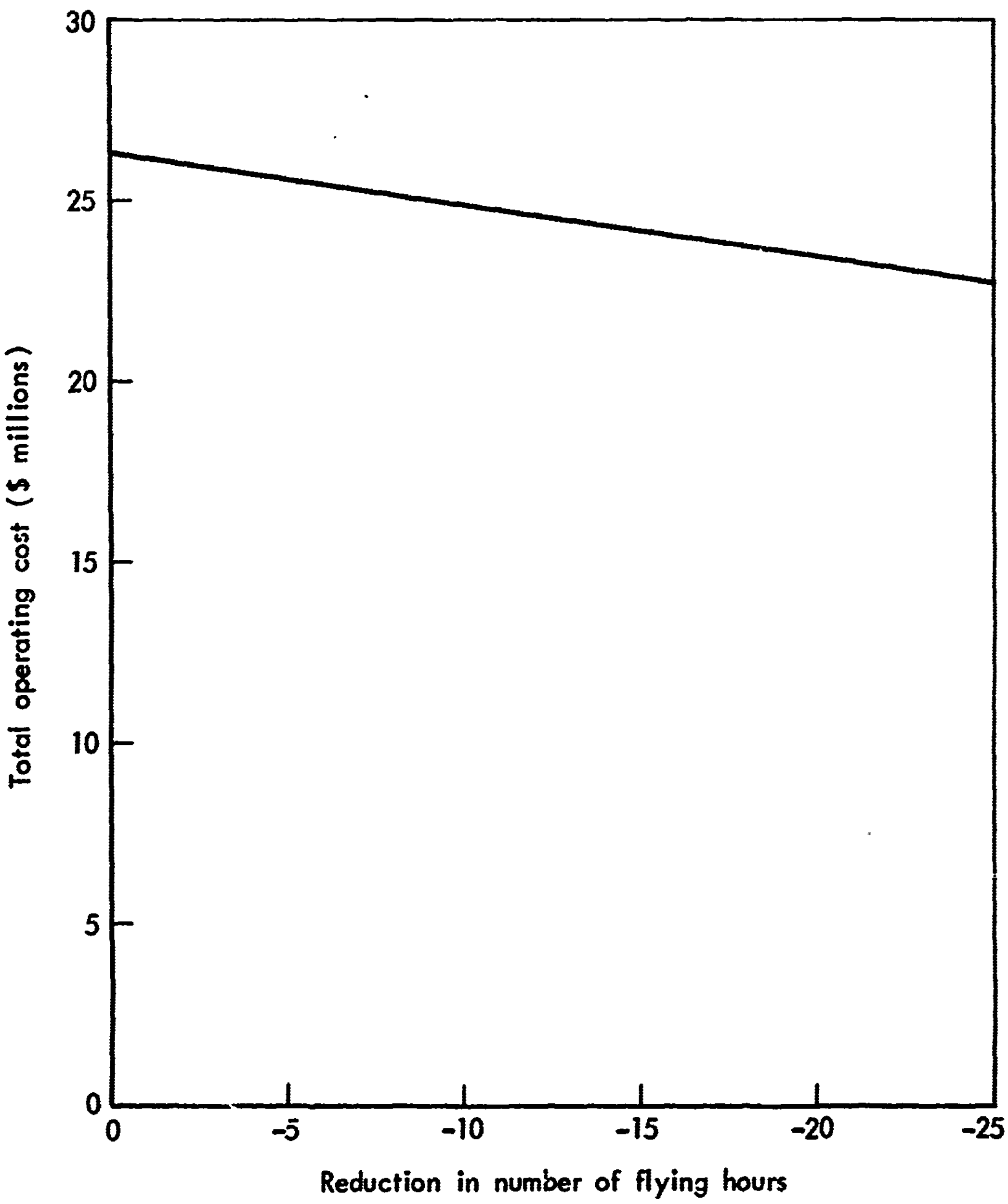


Fig. 12--Sensitivity Analysis, Weapon System A: Total Operating Cost vs. Reduction in Student and Instructor Flying Hours Resulting from Substitution of Simulators Hours on 2 for 1 Basis

falls by $388. A 20 percent reduction in flying hours with each flying hour being replaced by two simulator hours would reduce total operating cost and operating cost per graduate by 12 percent. If each flying hour were replaced by 6-1/2 simulator hours, operating costs would be almost constant.

An important aspect of this substitution of simulator training for flying training is the effect on investment. More simulator hours will require additional investment in simulators. At the same time, fewer flying hours will decrease the number of training aircraft required. In this example, substituting simulator hours for 20 percent of the flying hours would release six aircraft and require three more simulators.

VARIATION IN FRACTION OF STUDENTS WHO GRADUATE

The cost effects of variation in student attrition are examined on the assumption that the number of graduates required remains unchanged.

"Student attrition" is usually understood to mean the percentage of students who fail to complete a course. In the model, the fraction of students who graduate is used instead of "student attrition" in order to simplify calculations. In the base case, a one percent attrition rate appears as .99, the graduating fraction. As this fraction was varied, the number of entering students was changed just enough to provide a constant number of graduates.

The relationship between the fraction of students who graduate and total operating costs is represented by the curved line shown in Fig. 13.

The model treats those who fail to graduate as though they completed half of the course. The result is that the cost of partially training those who do not graduate is added to the cost of training those who do graduate.

If the fraction graduating declines 20 percent from .99 (the base case input) to .792, total operating cost for a constant number of graduates will increase about 12-1/2 percent.

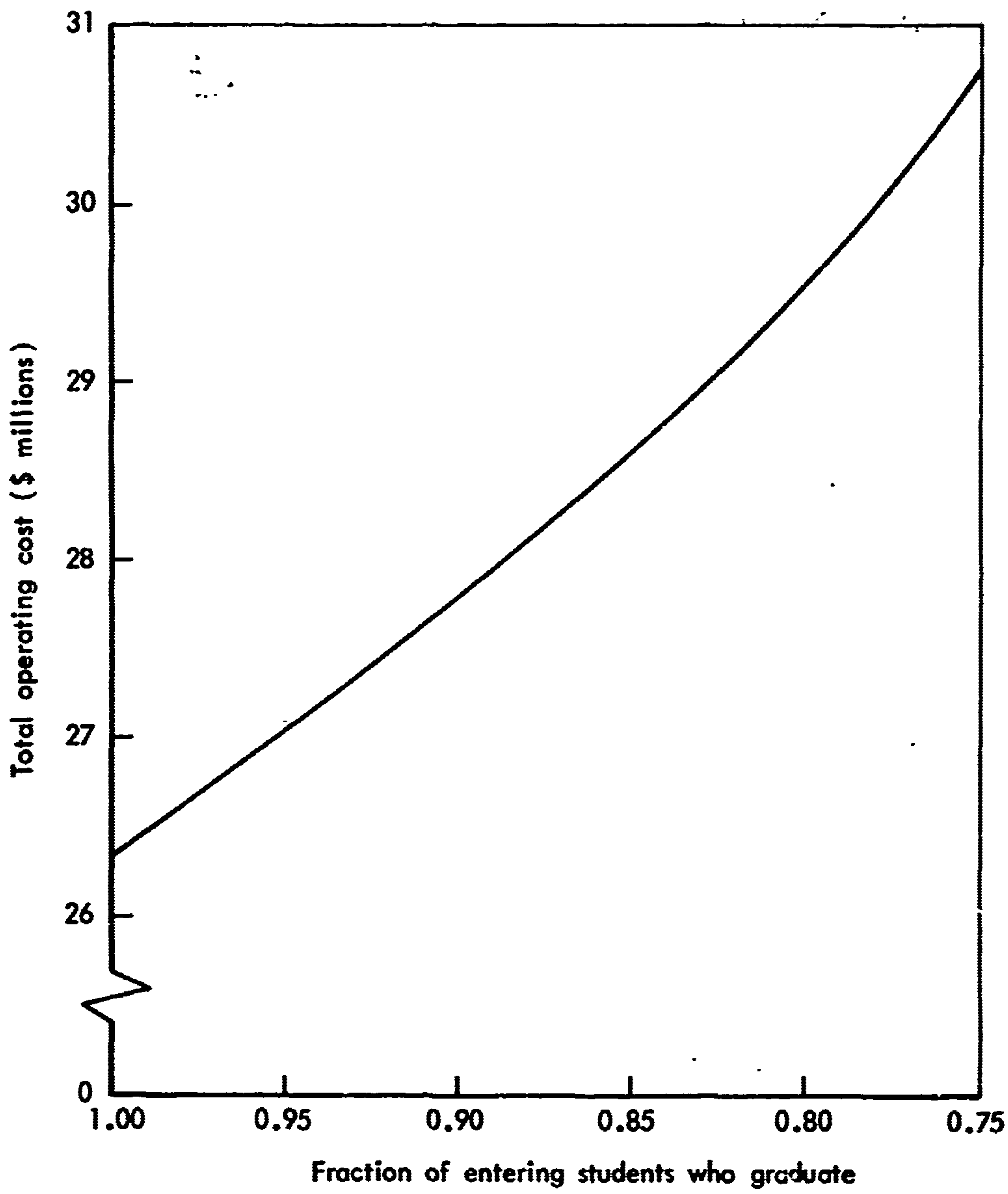


Fig. 13-- Sensitivity Analysis, Weapon System A:
Total Operating Cost vs. Fraction of
Entering Students who Graduate

The effect of student attrition on investment requirements is not examined here but the model could be used to explore this relationship.

VARIATION IN FLYING INSTRUCTOR WORKLOAD

The instructor-student ratio is an important factor in managing a training program. This ratio is not computed or used in the model but it can be easily determined since the number of instructors required and the number of students are outputs. In this example, the hours per year that a flight instructor may reasonably be expected to teach will be varied and the effect on costs noted. Changing the hours an instructor is available to fly with students alters the instructor-student ratio.

Figure 14 shows the slightly curvilinear relationship between total operating cost and the available flying instructor hours per year. All inputs, except the hours that one instructor would be expected to fly with students, were held constant. For any feasible change in flying instructor hours, the corresponding percentage change in operating cost is relatively small. If the instructor work load of 425 hours per year in the base case is decreased 20 percent to 340 hours, total operating cost is increased only 1 percent.

The student-instructor ratio--average student load divided by the number of required flying instructors--is 2.69 for the base case. Decreasing the workload by 20 percent changes this ratio to 2.15.

Relative Sensitivity of Operating Cost Per Graduate

The four examples presented above have been shown to demonstrate how the model may be used to examine the effects on pilot training costs of changes in one or more inputs. To bring out more clearly the differences in the sensitivity of cost to changes in selected variables, the operating cost per graduate instead of total operating costs are compared in Fig. 15 for these four examples. Only three points have been plotted: 0, 10, and 20. Although it is not obvious from the chart, only one of the four lines is straight-flying hours. On an expanded scale and with more plot points, the other three would appear as curves.

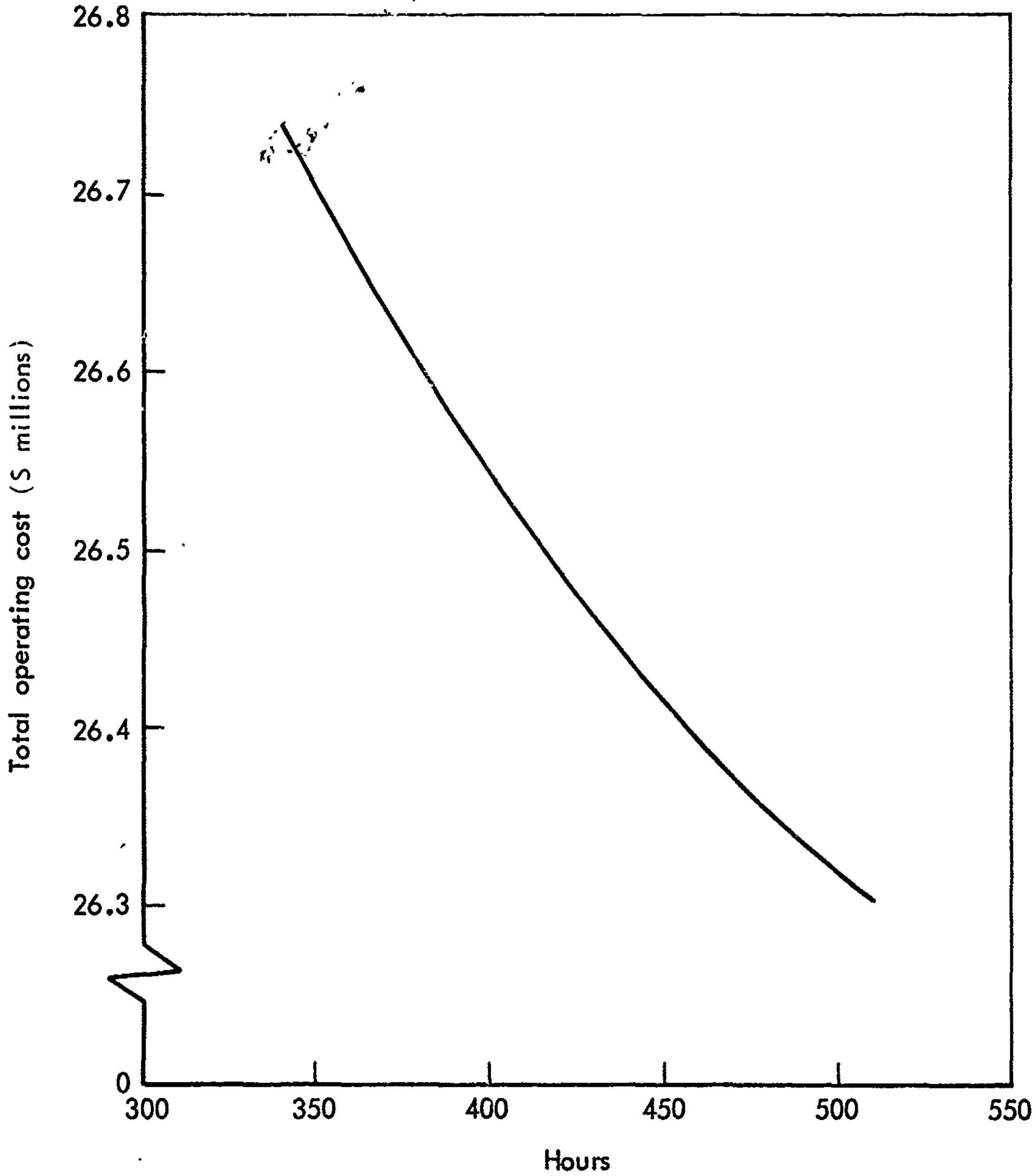


Fig. 14--Sensitivity Analysis, Weapon System A: Total Operating Cost vs. Hours Per Year Instructor is Available to Fly With Students

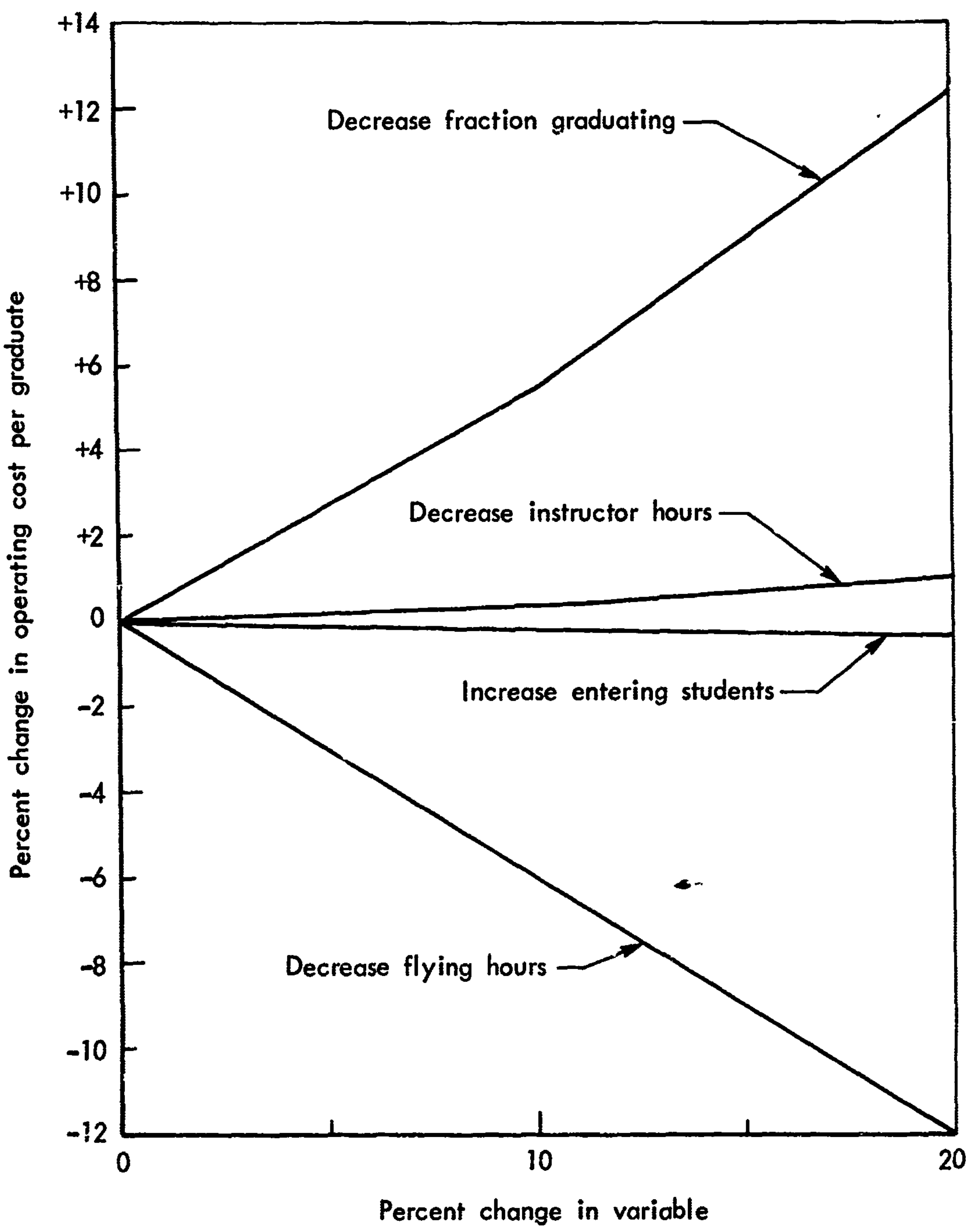


Fig. 15--Sensitivity Analysis, Weapon System A: Comparison of Percentage Changes in Operating Cost Per Graduate Caused by Changes in Selected Variables

It is apparent that the same percentage change in selected variables results in cost effects of significantly different magnitude. Changes in instructor work loads (student-instructor ratios), for example, offer small opportunity for savings in contrast to the large savings possible from a reduction in flying hours. The APT computer program may be used to test the effects of varying any of the inputs.

VI. CONCLUSION

In this Memorandum, a cost and resource estimating model for advanced pilot training is described and the more important problems encountered in its development are discussed. The relationships used in the model and the computer program are presented by simplified diagrams in Section III and equations in Section IV. The computer program has been tested extensively and the reasonableness of the results has been checked against estimates from other sources. Some of the test results are given in Section V dealing with sensitivity analysis.

The more difficult problems encountered in developing this model are attributable to the great diversity of formal advanced pilot training and to the requirement that pilot costs be segregated from other costs with which they are always commingled.

Estimates of pilot training costs will vary depending upon the assumptions made, the elements included and the validity of the input data. The selection of inputs is left to the judgment of the user of the model. A considerable effort will be required to assemble the original set of computer inputs but, once a base case has been established, modifications and updating will be relatively easy. The inputs for specific weapon systems probably can be determined most readily by the staffs of the schools concerned.

This model, used alone or in conjunction with the other models developed in the Pilot Training Study, will facilitate long-range planning and analysis of advanced pilot training programs.

Appendix

DERIVATION OF THE ADJUSTMENT EQUATION

Changes in permanent party personnel must be adjusted to prevent a year-to-year change in any allocation fraction from producing a spurious estimate of certain investment requirements.

When training program requirements (inputs) are increased, the computer calculates a corresponding increase in the number of permanent party personnel. In situations where both pilots and nonpilots are being trained, the portion of the personnel increase that is attributable to pilot training becomes the basis for the computation of additional pilot training costs in these four investment cost categories:

1. Base support equipment and spares - F(268).
2. Supply inventories - F(269).
3. Training - F(270).
4. Travel (PCS) - F(271).

Additional investment costs are incurred, in these categories, only if there is an actual increase in the number of permanent party personnel The increased costs are then charged to pilot training only when and to the extent that the additional personnel are earmarked for the pilot training program.

The foregoing does not apply in situations where the increase in the number of permanent party personnel charged to pilot training is exactly off-set by a decrease in the number allotted to nonpilot training. That is, if the increase in the number of personnel attributed to pilot training is solely due to the application of a larger allocation fraction, no increase is required in the cost of any of the investment categories listed above.* When the allocation fraction is increased, more people are charged to pilot training leaving a smaller number available for nonpilot training. Thus, there is no increase in the total number of permanent party personnel and, consequently, no

*The computer program will not generate a spurious investment requirement for any of the other investment categories as the result of an allocation fraction change.

need for increases in these investment categories. Therefore, when the allocation fraction for pilot training is changed from one year to the next, during a single computer run, an adjustment must be made to nullify the introduction of a nonexistent investment cost increase.

The derivation of the equation used to compute the amount of the adjustment is explained below.

To simplify the development of the adjustment equation, assume that there is no change in any input from one year to the next except that the allocation fraction for aircraft - Type 1 is increased.

Then

$$\Delta F(197) = F(194)[F(050)_t - F(050)_{t-1}] \qquad (1)$$

where $\Delta F(197)$ = increase in flying hours charged to pilot training - Type 1,

$F(194)$ = total flying hours - Type 1,

$F(050)_t$ = allocation fraction for current year,

$F(050)_{t-1}$ = allocation fraction for preceding year.

The increase in flying hours charged will affect the number of aircraft maintenance personnel. Therefore

$$\Delta F(231) = F(068) \cdot F(194)[F(050)_t - F(050)_{t-1}] \qquad (2)$$

where $\Delta F(231)$ = increase in aircraft maintenance personnel - Type 1,

$F(068)$ = aircraft maintenance personnel required per flying hour - Type 1.

The increase in maintenance personnel for aircraft - Type 1 calls for more administrative personnel (wing level).

Therefore

$$\Delta F(239) = F(074) \cdot \Delta F(231) \qquad (3)$$

where $\Delta F(239)$ = increase in administrative personnel (wing level),
$F(074)$ = variable number of administrative personnel (wing level) per operating and maintenance person.

More support personnel are required because of the preceding increases. Therefore

$$\Delta F(241) = F(076)[\Delta F(231) + \Delta F(239)] \tag{4}$$

where $\Delta F(241)$ = increase in support personnel,
$F(076)$ = variable number of support personnel per person in total of student load, operations, maintenance and administrative personnel.

Total increase in permanent party personnel resulting from an increase in an allocation fraction for aircraft - Type 1 is the sum of the foregoing items.

$$\Delta F(243) = \Delta F(231) + \Delta F(239) + \Delta F(241) \tag{5}$$

where $\Delta F(243)$ = increase in permanent party personnel.

Substituting for $\Delta F(239)$ and $\Delta F(241)$ gives the following:

$$\begin{aligned}\Delta F(243) &= \Delta F(231) + F(074) \cdot \Delta F(231) \\ &\quad + F(076)[\Delta F(231) + F(074) \cdot \Delta F(231)], \\ &= [1 + F(074) + F(076) + F(074) \cdot F(076)][\Delta F(231)], \\ &= [1 + F(074)][1 + F(076)][\Delta F(231)] \end{aligned} \tag{6}$$

Expanding Eq. (6) to allow for changes in the allocation fractions for aircraft types 2 and 3 and the simulator, yields

$$\begin{aligned}\Delta F(243) &= [1 + F(074)][1 + F(076)][\Delta F(231) + \Delta F(232) \\ &\quad + \Delta F(233) + \Delta F(235)]\end{aligned} \tag{7}$$

where $\Delta F(232)$ = increase in aircraft maintenance personnel - Type 2,

$\Delta F(233)$ = increase in aircraft maintenance personnel - Type 3,

$\Delta F(235)$ = increase in simulator operating and maintenance personnel.

$\Delta F(243)$ is the increase in permanent party personnel caused solely by the change in allocation fractions; it is the adjustment [F(255)] required to prevent calculation of a spurious investment requirement.

If the expression from Eq. (2) is used for $\Delta F(231)$ together with similar exoressions for $\Delta F(232)$, $\Delta F(233)$, and $\Delta F(234)$, Eq. (7) in the model appears as follows:

$$F(255) = \Big\{[1 + F(074)][1 + F(076)]\Big\}\Big\{[F(050)_t - F(050)_{t-1}][F(068)] [F(194)] + [F(051)_t - F(051)_{t-1}][F(069)][F(195)] + [F(052)_t - F(052)_{t-1}][F(070)][F(196)] + [F(135)_t - F(135)_{t-1}] [F(178)][F(071)]\Big\} \qquad (8)$$

(To identify any variable see list in Figs. 5 through 10.)

Since operating and maintenance personnel for simulators may be calculated by either of two methods, the adjustment equation also has two variations. In Eq. (8) above, F(178) is used and $F(071) < 1$ which is appropriate when simulator hours are the basis for estimating operating and maintenance personnel. When simulator operating and maintenance personnel are computed on tne basis of number of simulators, F(208) is substituted for F(178) and $F(071) \geq 1$.

The amount of the adjustment [F(255)] is subtracted from the change in permanent party personnel [F(252)]. The adjusted change in permanent party personnel is then used in computing investment requirements.

DOCUMENT CONTROL DATA

1. ORIGINATING ACTIVITY The Rand Corporation	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

THE PILOT TRAINING STUDY: A COST-ESTIMATING MODEL FOR ADVANCED PILOT TRAINING

4. AUTHOR(S) (Last name, first name, initial)

Knollmeyer, L. E.

5. REPORT DATE	6a. TOTAL NO. OF PAGES	6b. NO. OF REFS.
December 1969	93	---

7. CONTRACT OR GRANT NO.	8. ORIGINATOR'S REPORT NO.
F44620-67-C-0045	RM-6086-PR

9a. AVAILABILITY/LIMITATION NOTICES	9b. SPONSORING AGENCY
DDC-1	United States Air Force Project RAND

10. ABSTRACT

A description of the structure of the APT model and the problems encountered in its development. The model is designed for estimating the required resources and costs of training pilots to fly more than 50 different types of USAF aircraft. The model consists of detailed statements, in logical sequence, of the relationships among factors significantly affecting training costs, such as the relationship between numbers of students and instructors. These relationships are incorporated in a computer program, which, when given the appropriate inputs, e.g., students, aircraft type, and course length, calculates the incremental time-phased requirements for personnel, equipment, and services and their associated costs. Resources and costs are computed by weapon system on an annual basis. The model may be used for any number of weapon systems and years. Results of general interest are output in a standard table, but any or all inputs and outputs may be made available, optionally, for analysis. Total operating cost, incremental investment cost, and operating cost per graduate are computed. Resource requirements include personnel, aircraft, and simulators; facilities are excluded.

11. KEY WORDS

Pilots
Air Force
Education and training
Cost estimates
Models
Computer simulation